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STRENGTH DETERMINATIONS OF ELDRICH MINE ROCKS

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STRENGTH DETERMINATIONS OF ELDRICH MINE ROCKS

by

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ABSTRACT

Laboratory tests were conducted on drill cores originating from previous diamond drilling activity at Eldrich Mine, Quebec. The results of strength and deformation properties of 246 test specimens are presented in this report.

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1. INTRODUCTION

Drill core samples were received at MRL from Eldrich Mine boreholes 1, 2, 3, 335, 336 and 337. An MTS 815 Rock Mechanics Test System was used in the test program. Uniaxial and triaxial tests were conducted using computer software to control the servo-hydraulic test system. The results of strength and deformation property tests are presented in this report. The program was completed in April 1988. Results will be used in rock mass characterization, in-situ stress determination, pillar strength determination, monitoring, back analyses and numerical modelling.

2. TEST PROCEDURE

SPECIMEN SELECTION

Triaxial, uniaxial and brazilian tests were conducted on rock specimens cut from each received core. The individual test specimens were coded as follows:

Example E36M

E - mine name code

36 - specimen number

M - test type

The codes used for identification of test types are:

U - uniaxial test

M - multi-stage triaxial test

B - brazilian test

The specimen location, test type, dimensions and density, δ, of each tested specimen are listed in Table 1.

SPECIMEN PREPARATION

Rock core sample specimens selected for uniaxial and triaxial tests were prepared with length to diameter ratios of approximately 2:1. Brazilian tensile strength specimens were prepared with length to diameter ratios of 1:2. All specimens were lapped to within the specified tolerances, oven dried, weighed and dimensioned. Prior to testing planes of discontinuity, if any, or potential weaknesses were highlighted on the specimens with ink. The specimen preparation was performed according to the procedures used at MRL [1,2].

BRAZILIAN TEST

Test specimens were loaded to failure using a 1300 kN compression press [3]. The test procedure conformed to ISRM suggested methods [4].

UNIAXIAL POST-FAILURE TEST

The specimen is uniaxially loaded, under load control mode, at the rate of 1kN/s. When the circumferential dilation of the specimen has reached 0.02 mm magnitude the axial load is reduced by 20%. The control mode is then switched over to circumferential displacement control. The test is continued, at a circumferential displacement rate of 0.0013 mm/s, through the peak strength until the residual strength is visually established, as indicated by a plateau in the graph recorded by the X Y recorder. The test is then terminated.

MULTI - STAGE TRIAXIAL TEST

The specimen is triaxially loaded, under load control mode, by the simultaneous application of axial load and confining pressure, at the rate of 1 kN/s. When the desired confining pressure of the first stage is reached, the axial loading is continued, at the rate of 1 kN/s while the confining pressure is kept constant. When circumferential dilation of the specimen has reached 0.02 mm magnitude the axial load is reduced by 20%. The control mode is then switched over to circumferential displacement control. The test is continued, at a circumferential displacement rate of 0.0013 mm/s, until an initial failure has occured as detected by an axial load drop.

The desired confining pressure of the second stage is applied, and so on, until the procedure is completed for each predetermined increment of confining pressure.

The confining pressure of the last stage is held through the peak strength until the residual strength is visually established, as indicated by a plateau in the graph recorded by the X Y recorder. The control is then switched over to axial displacement control mode. The specimen is further compressed axially for an additional displacement of 0.125 mm, at a rate of 0.002 mm/s, while the confining pressure is linearly reduced to zero within the time period of 60 seconds. This last phase of the test is required for residual strength data.

DATA ACQUISITION/REDUCTION

Data was scanned and stored by the computer every 3 seconds. Signals from the load cell, circumferential extensometer, axial LVDTs, confinement pressure, and axial and circumferential strain gauges were scanned. Real time plotting of load versus axial displacement was obtained using a HP7046B X Y1 Y2 pen recorder wired to a MTS 448.85 controller.

The raw signals were reduced to engineering units and stored on hard disk for later recall. Measurements from axial LVDTs were corrected for end platen compression in the sensing gauge length. Reduced data was transferred to a VAX 750 computer for determination of specimen material constants. Hard copy plots of test results for report purposes were obtained using the DEC LVP16 pen plotter. The DEC LA50 printer was used to provide hard copies of reduced data for analyses.

3. TEST RESULTS

TENSILE STRENGTH

The tensile strength results, σ_t, obtained by Brazilian test, are listed in Table 2.

UNIAXIAL COMPRESSIVE STRENGTH

The peak strain values, ϵ_{peak}, listed in Table 3, were determined by averaging the readings from the 3 axial LVDTs and the axial strain gauges. The uniaxial compressive strength results, Q_u, are also listed in Table 3.

Appendix A contains stress-strain curve plots utilizing signals from LVDTs for strain measurement. Appendix C provides stress-strain plots using signals from axial strain gauges mounted on the specimen surface. The gauges failed prior to test completion due to specimen fracture propagation. The plots in Appendix B are based on signals from the circumferential extensometer. The extensometer was located at mid-height of the specimen over mylar tape. The tape minimized rock spalling and reduced adverse extensometer signals. Appendix D contains curve plots derived from signals from strain gauges circumferentially mounted on the specimen surface. Specimen fracture propagation resulted in the gauges failing prior to test completion.

ELASTIC CONSTANTS

The modulus of elasticity, E, and the Poisson's ratio, ν, were established in each uniaxial compressive test case using load cell, LVDT and strain gauge data. E values based on axial LVDT readings are provided in Table 3. Modulus of elasticity values are based on axial strain gauge values. Poisson's ratio was calculated using axial and circumferential strain gauge and LVDT readings. The obtained results are listed in Table 3.

Relatively high values of Poisson's ratio can be accounted for by gauge bonding either from material porosity or higher gneissocity that prevented good adhesive bonding.

TRIAXIAL COMPRESSIVE STRENGTH

The triaxial compressive strengths of the selected specimens were determined at successive confining stages of: 1,2,3,4,5 and 10 MPa or 2,4,6,8 and 10 MPa.

The stress-strain curve plots of the multi-stage triaxial tests are found in Appendix E. Strain measurements were provided from LVDT signals. Appendix F contains stress-strain curve plots using circumferential extensometer signals. The plots in Appendix G demonstrate the relationships between post-failure strength and confining pressure.

The results of the multi-stage tests are tabulated in Table 4.

4. ROCK CHARACTERIZATION

All of the tested specimens exhibited elastic behaviour, essentially for the entire range of loading, and brittle failure characteristics. The majority of specimens failed along planes of weakness or discontinuities.

5. REFERENCES

1. Gorski, B. "The design and operation of a stiff triaxial assembly for post-failure rock property testing"; *Division Report MRP/MRL*82 – 81(*TR*); CANMET, Energy, Mines and Resources Canada; 1982.

2. Gyenge, M. and Herget, G. "Pit slope Manual 3-2; Laboratory tests for design parameters"; *CANMET Report* 77 – 26; CANMET, Energy, Mines and Resources Canada; 1977.

3. Gorski, B. "A multi-use load system for rock testing";*Division Report M&ET/MRL*86–25(*TR*); CANMET, Energy, Mines and Resources Canada; 1986.

4. Brown, E.T. "Rock characterization testing and monitoring"; *ISRM*; *Pergamon Press, London, England*; 211p; 1981.

Table 1 Specimen selection data

Sample Number	Depth (m)	Borehole Number	Test Type	Length (mm)	Diameter (mm)	δ (g/cm^3)
E01U	9.42	88-003	Uniaxial	96.86	47.50	2.67
E02M	11.15	88-003	Triaxial	96.84	47.40	2.68
E03U	11.51	88-003	Uniaxial	97.08	47.40	2.70
E04M	12.73	88-003	Triaxial	97.16	47.26	2.71
E05U	12.83	88-003	Uniaxial	97.26	47.24	2.71
E06M	13.92	88-003	Triaxial	97.06	47.30	2.67
E07U	14.35	88-003	Uniaxial	97.08	47.30	2.72
E08M	14.45	88-003	Triaxial	96.76	47.32	2.74
E09U	14.55	88-003	Uniaxial	97.16	47.30	2.73
E10M	14.68	88-003	Triaxial	96.90	47.28	2.71
E11U	14.78	88-003	Uniaxial	96.94	47.30	2.70
E12M	14.99	88-003	Triaxial	95.98	47.30	2.72
E13U	15.85	88-003	Uniaxial	97.58	47.44	2.70
E14M	16.00	88-003	Triaxial	98.32	47.46	2.74
E15U	16.38	88-003	Uniaxial	95.44	47.42	2.72
E16M	17.70	88-003	Triaxial	96.64	47.30	2.72
E17U	18.24	88-003	Uniaxial	96.80	47.30	2.71
E18M	18.41	88-003	Triaxial	97.68	47.32	2.70
E19U	19.02	88-003	Uniaxial	97.48	47.54	2.71
E20M	19.20	88-003	Triaxial	97.86	47.52	2.75
E21U	11.84	88-001	Uniaxial	98.68	47.44	2.84
E22M	11.94	88-001	Triaxial	99.32	47.40	2.85
E23U	12.29	88-001	Uniaxial	95.32	47.42	2.89
E24M	12.39	88-001	Triaxial	99.38	47.36	2.89
E25U	14.66	88-001	Uniaxial	99.92	47.40	2.95
E26M	15.19	88-001	Triaxial	96.48	47.40	2.96
E27U	15.29	88-001	Uniaxial	96.60	47.40	2.95
E28M	15.49	88-001	Triaxial	96.58	47.40	2.96
E29U	15.65	88-001	Uniaxial	95.50	47.40	2.95
E30M	11.02	88-002	Triaxial	96.48	47.46	2.99
E31U	11.68	88-002	Uniaxial	96.46	47.44	2.98
E32M	12.55	88-002	Triaxial	96.28	47.44	2.97
E33U	12.80	88-002	Uniaxial	96.28	47.42	3.00
E34M	12.65	88-002	Triaxial	96.42	47.44	2.98
E35U	13.51	88-002	Uniaxial	96.18	47.46	2.89

Table 1 Specimen selection data (cont'd)

Sample Number	Depth (m)	Borehole Number	Test Type	Length (mm)	Diameter (mm)	δ (g/cm^3)
E36M	14.02	88-002	Triaxial	95.64	47.44	2.94
E37U	14.17	88-002	Uniaxial	96.18	47.44	2.95
E38M	14.68	88-002	Triaxial	96.00	47.44	2.94
E39U	14.83	88-002	Uniaxial	95.98	47.44	2.95
E40M	16.74	88-001	Triaxial	97.16	47.40	2.88
E41U	16.84	88-001	Uniaxial	96.04	47.42	2.88
E42M	18.06	88-001	Triaxial	97.90	47.44	2.80
E43U	18.31	88-001	Uniaxial	98.84	47.46	2.79
E44M	18.49	88-001	Triaxial	93.94	47.46	2.80
E45U	19.28	88-001	Uniaxial	99.32	47.46	2.77
E46M	19.61	88-001	Triaxial	97.66	47.42	2.77
E47U	10.41	88-002	Uniaxial	98.28	47.44	2.86
E48M	15.85	88-002	Triaxial	98.14	47.38	2.76
E49U	15.98	88-002	Uniaxial	98.60	47.36	2.77
E50M	16.10	88-002	Triaxial	96.84	47.34	2.75
E51U	16.23	88-002	Uniaxial	97.88	47.36	2.75
E52M	16.64	88-002	Triaxial	97.46	47.40	2.76
E53U	16.79	88-002	Uniaxial	97.08	47.42	2.75
E54M	19.99	88-002	Triaxial	95.58	47.42	2.76
E55U	20.07	88-003	Uniaxial	97.68	47.44	2.77
E56M	20.17	88-003	Triaxial	97.36	47.40	2.76
E57U	5.40	88-335	Uniaxial	97.30	47.40	2.80
E58U	12.32	88-335	Uniaxial	96.76	47.64	2.79
E59U	14.28	88-335	Uniaxial	95.06	47.62	2.80
E60U	26.20	88-335	Uniaxial	94.02	47.48	2.80
E61M	5.60	88-335	Triaxial	98.79	47.40	2.78
E62M	12.43	88-335	Triaxial	96.88	47.64	2.77
E63M	17.42	88-335	Triaxial	94.90	47.42	2.80
E64M	26.32	88-335	Triaxial	94.74	47.46	2.80
E65M	34.47	88-335	Triaxial	96.08	47.38	3.01
E66M	41.56	88-335	Triaxial	96.48	47.40	2.99
E67M	45.84	88-335	Triaxial	96.36	47.36	2.88
E68M	59.44	88-335	Triaxial	97.26	47.10	2.71
E69M	62.72	88-335	Triaxial	94.46	47.06	2.79
E70M	52.26	88-335	Triaxial	95.30	47.38	2.77
E71M	56.30	88-335	Triaxial	95.44	47.40	2.76

Table 1 Specimen selection data (cont'd)

Sample Number	Depth (m)	Borehole Number	Test Type	Length (mm)	Diameter (mm)	δ (g/cm^3)
E72U	34.34	88-335	Uniaxial	96.40	47.40	3.02
E73U	41.33	88-335	Uniaxial	96.32	47.40	3.01
E74U	45.71	88-335	Uniaxial	97.48	47.42	2.84
E75U	52.01	88-335	Uniaxial	93.40	47.38	2.77
E76U	56.16	88-335	Uniaxial	93.32	47.38	2.76
E77U	59.14	88-335	Uniaxial	94.26	47.12	2.74
E78U	62.48	88-335	Uniaxial	93.94	47.08	2.77
E79U	21.06	88-336	Uniaxial	96.88	47.58	2.77
E80U	25.98	88-336	Uniaxial	96.54	47.16	2.78
E81U	31.28	88-336	Uniaxial	95.54	47.02	2.82
E82U	35.36	88-336	Uniaxial	94.84	47.18	2.80
E83U	40.39	88-336	Uniaxial	97.52	47.24	2.95
E84U	41.63	88-336	Uniaxial	95.80	47.26	2.86
E85U	47.56	88-336	Uniaxial	96.28	47.50	2.78
E86U	51.22	88-336	Uniaxial	91.00	47.10	2.80
E87U	56.95	88-336	Uniaxial	96.12	47.24	2.82
E88U	59.00	88-336	Uniaxial	95.28	47.22	2.81
E89U	61.65	88-336	Uniaxial	94.60	47.26	2.76
E90U	63.80	88-336	Uniaxial	95.00	47.26	2.76
E91U	64.37	88-336	Uniaxial	94.00	47.26	2.71
E92M	21.30	88-336	Triaxial	98.32	47.56	2.80
E93M	26.08	88-336	Triaxial	97.34	47.16	2.76
E94M	31.42	88-336	Triaxial	95.76	47.00	2.79
E95M	35.46	88-336	Triaxial	96.54	47.16	2.82
E96M	40.49	88-336	Triaxial	97.10	47.20	2.90
E97M	41.90	88-336	Triaxial	95.30	47.22	2.85
E98M	47.74	88-336	Triaxial	94.90	47.42	2.79
E99M	51.35	88-336	Triaxial	93.80	47.12	2.83
E100M	57.08	88-336	Triaxial	95.30	47.20	2.83
E101M	59.10	88-336	Triaxial	94.52	47.22	2.81
E102M	64.50	88-336	Triaxial	96.28	47.38	2.67

Table 1 Specimen selection data (cont'd)

Sample Number	Depth (m)	Borehole Number	Test Type	Length (mm)	Diameter (mm)	δ (g/cm^3)
E103U	12.43	88-337	Uniaxial	94.24	47.32	2.80
E104U	15.24	88-337	Uniaxial	94.60	47.34	2.79
E105U	17.40	88-337	Uniaxial	95.80	47.30	2.81
E106U	20.70	88-337	Uniaxial	94.42	47.36	2.79
E107U	24.29	88-337	Uniaxial	95.80	47.40	2.82
E108U	27.32	88-337	Uniaxial	97.76	47.36	2.94
E109U	28.20	88-337	Uniaxial	97.10	47.40	2.90
E110U	31.20	88-337	Uniaxial	95.58	47.38	2.94
E111U	33.97	88-337	Uniaxial	95.38	47.36	2.91
E112U	36.44	88-337	Uniaxial	96.98	47.38	2.81
E113U	45.19	88-337	Uniaxial	96.86	47.36	2.82
E114U	54.21	88-337	Uniaxial	97.96	47.46	chipped
E115U	55.75	88-337	Uniaxial	98.54	47.48	2.68
E116U	58.81	88-337	Uniaxial	99.12	47.46	chipped
E117U	60.95	88-337	Uniaxial	97.20	47.48	2.69
E118U	64.30	88-337	Uniaxial	95.00	47.60	2.73
E119M	12.33	88-337	Triaxial	93.70	47.40	2.79
E120M	15.14	88-337	Triaxial	96.10	47.40	2.79
E121M	17.54	88-337	Triaxial	96.16	47.36	2.79
E122M	20.85	88-337	Triaxial	92.52	47.38	2.79
E123M	24.45	88-337	Triaxial	94.84	47.40	2.83
E124M	27.49	88-337	Triaxial	95.94	47.40	2.92
E125M	28.30	88-337	Triaxial	95.88	47.42	2.89
E126M	31.33	88-337	Triaxial	96.18	47.40	2.96
E127M	33.63	88-337	Triaxial	94.60	47.42	2.89
E128M	36.56	88-337	Triaxial	99.00	47.40	2.77
E129M	54.36	88-337	Triaxial	93.38	47.50	2.65
E130M	55.92	88-337	Triaxial	91.90	47.50	2.63
E131M	58.94	88-337	Triaxial	95.30	47.44	2.65
E132M	61.17	88-337	Triaxial	97.32	47.50	2.71
E133M	64.42	88-337	Triaxial	95.64	47.62	2.70

Table 1 Specimen selection data (cont'd)

Sample Number	Depth (m)	Borehole Number	Test Type	Length (mm)	Diameter (mm)	δ (g/cm^3)
E61B	9.70	88-001	Brazilian	23.80	47.36	-
E62B	12.47	88-001	Brazilian	23.54	47.36	-
E63B	14.53	88-001	Brazilian	24.20	47.40	-
E64B	15.85	88-001	Brazilian	24.10	47.44	-
E65B	16.26	88-001	Brazilian	23.50	47.38	-
E66B	12.01	88-002	Brazilian	24.48	47.40	-
E67B	12.47	88-002	Brazilian	23.70	47.40	-
E68B	12.88	88-002	Brazilian	24.10	47.40	-
E69B	13.56	88-002	Brazilian	24.00	47.42	-
E70B	14.12	88-002	Brazilian	24.08	47.40	-
E71B	20.02	88-003	Brazilian	23.22	47.36	-
E72B	20.85	88-003	Brazilian	23.10	47.00	-
E73B	16.94	88-001	Brazilian	22.78	47.40	-
E74B	17.22	88-001	Brazilian	22.50	47.42	-
E75B	17.98	88-001	Brazilian	23.42	47.42	-
E76B	18.87	88-001	Brazilian	24.48	47.40	-
E77B	19.41	88-001	Brazilian	24.00	47.46	-
E78B	11.20	88-002	Brazilian	24.48	47.44	-
E79B	11.33	88-002	Brazilian	23.72	47.40	-
E80B	15.93	88-002	Brazilian	24.86	47.36	-
E81B	16.84	88-002	Brazilian	24.14	47.40	-
E82B	18.26	88-002	Brazilian	24.12	47.40	-
E83B	18.62	88-002	Brazilian	23.80	47.36	-
E84B	19.13	88-002	Brazilian	23.80	47.40	-
E85B	21.41	88-002	Brazilian	23.42	47.22	-
E86B	21.56	88-002	Brazilian	23.88	47.32	-
E87B	9.75	88-003	Brazilian	23.56	47.46	-
E88B	10.11	88-003	Brazilian	22.68	47.42	-
E89B	10.87	88-003	Brazilian	23.54	47.40	-
E90B	16.56	88-003	Brazilian	22.26	47.40	-
E91B	16.13	88-003	Brazilian	23.28	47.40	-
E92B	14.88	88-003	Brazilian	23.74	47.26	-
E93B	13.82	88-003	Brazilian	24.44	47.24	-
E94B	12.98	88-003	Brazilian	23.34	47.24	-
E95B	17.48	88-003	Brazilian	24.14	47.26	-
E96B	18.97	88-003	Brazilian	24.08	47.50	-

Table 1 Specimen selection data (cont'd)

Sample Number	Depth (m)	Borehole Number	Test Type	Length (mm)	Diameter (mm)	δ (g/cm^3)
E97B	5.31	88-335	Brazilian	21.86	47.40	2.78
E98B	5.48	88-335	Brazilian	23.06	47.40	2.78
E99B	12.17	88-335	Brazilian	24.30	47.64	2.79
E100B	12.50	88-335	Brazilian	24.08	47.64	2.76
E101B	14.39	88-335	Brazilian	25.42	47.62	2.79
E102B	17.48	88-335	Brazilian	22.54	47.42	2.80
E103B	26.14	88-335	Brazilian	25.44	47.52	2.78
E104B	26.26	88-335	Brazilian	25.22	47.48	2.80
E105B	34.41	88-335	Brazilian	23.50	47.40	-
E106B	35.54	88-335	Brazilian	24.36	47.40	-
E107B	41.49	88-335	Brazilian	24.72	47.40	-
E108B	41.39	88-335	Brazilian	25.14	47.42	-
E109B	45.78	88-335	Brazilian	25.00	47.42	-
E110B	45.90	88-335	Brazilian	24.46	47.34	-
E111B	52.08	88-335	Brazilian	24.38	47.40	-
E112B	52.14	88-335	Brazilian	25.12	47.36	-
E113B	56.10	88-335	Brazilian	22.48	47.40	-
E114B	56.22	88-335	Brazilian	24.14	47.40	-
E115B	59.07	88-335	Brazilian	25.08	47.10	-
E116B	59.32	88-335	Brazilian	24.54	47.10	-
E117B	62.66	88-335	Brazilian	23.70	47.00	-
E118B	62.78	88-335	Brazilian	21.80	47.06	-
E119B	20.93	88-336	Brazilian	23.76	47.62	-
E120B	21.00	88-336	Brazilian	25.20	47.56	-
E121B	25.92	88-336	Brazilian	24.12	47.14	-
E122B	26.20	88-336	Brazilian	24.56	47.16	-
E123B	31.22	88-336	Brazilian	25.28	47.02	-
E124B	31.35	88-336	Brazilian	25.22	47.05	-
E125B	35.30	88-336	Brazilian	24.78	47.16	-
E126B	35.52	88-336	Brazilian	23.86	47.18	-
E127B	40.30	88-336	Brazilian	24.32	47.30	-
E128B	40.56	88-336	Brazilian	24.50	47.22	-
E129B	41.56	88-336	Brazilian	23.70	47.26	-
E130B	41.83	88-336	Brazilian	23.48	47.20	-
E131B	47.50	88-336	Brazilian	24.06	47.36	-
E132B	51.16	88-336	Brazilian	24.92	47.12	-
E133B	51.29	88-336	Brazilian	24.56	47.12	-
E134B	56.89	88-336	Brazilian	22.20	47.26	-
E135B	57.14	88-336	Brazilian	24.10	47.24	-

Table 1 Specimen selection data (cont'd)

Sample Number	Depth (m)	Borehole Number	Test Type	Length (mm)	Diameter (mm)	δ (g/cm^3)
E136B	58.94	88-336	Brazilian	25.30	47.16	-
E137B	59.18	88-336	Brazilian	22.70	47.22	-
E138B	61.52	88-336	Brazilian	23.94	47.26	-
E139B	63.74	88-336	Brazilian	22.86	47.26	-
E140B	64.30	88-336	Brazilian	24.64	47.28	-
E141B	64.65	88-336	Brazilian	25.30	47.30	-
E142B	12.15	88-337	Brazilian	25.00	47.40	2.79
E143B	12.18	88-337	Brazilian	23.62	47.40	2.78
E144B	14.85	88-337	Brazilian	25.06	47.38	2.80
E145B	14.88	88-337	Brazilian	23.98	47.38	2.80
E146B	14.91	88-337	Brazilian	24.66	47.40	2.79
E147B	17.34	88-337	Brazilian	23.80	47.34	2.80
E148B	17.47	88-337	Brazilian	23.78	47.34	2.80
E149B	20.79	88-337	Brazilian	23.20	47.38	2.80
E150B	20.92	88-337	Brazilian	24.02	47.40	2.78
E151B	24.35	88-337	Brazilian	24.48	47.40	2.79
E152B	24.39	88-337	Brazilian	23.84	47.40	2.83
E153B	27.26	88-337	Brazilian	23.94	47.44	2.92
E154B	27.43	88-337	Brazilian	24.60	47.44	2.91
E155B	28.40	88-337	Brazilian	23.94	47.42	2.87
E156B	28.43	88-337	Brazilian	24.46	47.44	2.85
E157B	31.13	88-337	Brazilian	23.36	47.40	2.89
E158B	31.40	88-337	Brazilian	23.88	47.40	2.96
E159B	33.56	88-337	Brazilian	24.36	47.40	2.90
E160B	33.90	88-337	Brazilian	24.32	47.36	2.88
E161B	36.37	88-337	Brazilian	23.46	47.38	2.78
E162B	36.51	88-337	Brazilian	24.64	47.38	2.80
E163B	45.30	88-337	Brazilian	24.46	47.40	2.78
E164B	45.41	88-337	Brazilian	24.34	47.36	2.82
E165B	54.12	88-337	Brazilian	22.96	47.46	2.64
E166B	54.43	88-337	Brazilian	24.70	47.48	2.64
E167B	55.56	88-337	Brazilian	23.92	47.48	2.65
E168B	55.60	88-337	Brazilian	22.40	47.50	chipped
E169B	58.69	88-337	Brazilian	25.02	47.44	2.64
E170B	61.06	88-337	Brazilian	24.38	47.50	2.66
E171B	61.24	88-337	Brazilian	24.56	47.50	2.68
E172B	64.23	88-337	Brazilian	24.82	47.60	2.71
E173B	64.36	88-337	Brazilian	24.66	47.60	2.69
E174B	64.58	88-337	Brazilian	23.50	47.60	2.67

Table 2 Brazilian tensile strength

Sample Number	Depth (m)	Borehole Number	Failure load (kN)	σ_t (MPa)
E61B	9.70	88-001	22.05	-12.44
E62B	12.47	88-001	36.84	-21.01
E63B	14.53	88-001	29.37	-16.29
E64B	15.85	88-001	41.70	-23.20
E65B	16.26	88-001	30.65	-17.51
E66B	12.01	88-002	41.67	-22.84
E67B	12.47	88-002	35.72	-20.22
E68B	12.88	88-002	45.16	-25.13
E69B	13.56	88-002	46.74	-26.12
E70B	14.12	88-002	23.65	-13.18
E71B	20.02	88-003	31.79	-18.39
E72B	20.85	88-003	12.58	-7.37
E73B	16.94	88-001	17.86	-10.52
E74B	17.22	88-001	18.70	-11.15
E75B	17.98	88-001	14.63	-8.38
E76B	18.87	88-001	21.74	-11.92
E77B	19.41	88-001	13.65	-7.62
E78B	11.20	88-002	3.26	-1.78
E79B	11.33	88-002	11.63	-6.58
E80B	15.93	88-002	17.63	-9.52
E81B	16.84	88-002	14.14	-7.86
E82B	18.26	88-002	19.40	-10.79
E83B	18.62	88-002	6.26	-3.53
E84B	19.13	88-002	13.98	-7.88
E85B	21.41	88-002	19.93	-11.46
E86B	21.56	88-002	15.91	-8.95
E87B	9.75	88-003	21.86	-12.43
E88B	10.11	88-003	34.88	-20.63
E89B	10.87	88-003	31.26	-17.82
E90B	16.56	88-003	26.30	-15.85
E91B	16.13	88-003	22.05	-12.71
E92B	14.88	88-003	37.70	-21.37
E93B	13.82	88-003	13.91	-7.66
E94B	12.98	88-003	29.40	-16.96
E95B	17.48	88-003	30.98	-17.27
E96B	18.97	88-003	18.28	-10.16

Table 2 Brazilian tensile strength (cont'd)

Sample Number	Depth (m)	Borehole Number	Failure load (kN)	σ_t (MPa)
E97B	5.31	88-335	33.56	-20.60
E98B	5.48	88-335	40.28	-23.44
E99B	12.17	88-335	28.26	-16.36
E100B	12.50	88-335	18.49	-10.25
E101B	14.39	88-335	18.28	-9.60
E102B	17.48	88-335	25.16	-14.97
E103B	26.14	88-335	36.79	-19.36
E104B	26.26	88-335	33.33	-17.70
E105B	34.41	88-335	28.81	-16.45
E106B	35.54	88-335	35.65	-19.63
E107B	41.49	88-335	38.56	-20.93
E108B	41.39	88-335	45.70	-24.38
E109B	45.78	88-335	32.44	-17.40
E110B	45.90	88-335	28.95	-15.90
E111B	52.08	88-335	10.00	-5.50
E112B	52.14	88-335	13.84	-7.40
E113B	56.10	88-335	13.84	-8.26
E114B	56.22	88-335	15.21	-8.45
E115B	59.07	88-335	26.95	-14.51
E116B	59.32	88-335	21.88	-12.04
E117B	62.66	88-335	33.98	-19.40
E118B	62.78	88-335	15.65	-15.25
E119B	20.93	88-336	28.35	-15.94
E120B	21.00	88-336	18.14	-9.63
E121B	25.92	88-336	29.77	-16.65
E122B	26.20	88-336	8.37	-4.60
E123B	31.22	88-336	26.74	-14.31
E124B	31.35	88-336	23.02	-12.34
E125B	35.30	88-336	12.56	-6.84
E126B	35.52	88-336	19.30	-10.90
E127B	40.30	88-336	20.70	-17.99
E128B	40.56	88-336	25.81	-14.19
E129B	41.56	88-336	26.28	-14.92
E130B	41.83	88-336	30.23	-17.45
E131B	47.50	88-336	27.67	-15.44
E132B	51.16	88-336	17.91	-9.70
E133B	51.29	88-336	14.65	-8.05
E134B	56.89	88-336	24.19	-14.66
E135B	57.14	88-336	32.09	-17.53

Table 2 Brazilian tensile strength (cont'd)

Sample Number	Depth (m)	Borehole Number	Failure load (kN)	σ_t (MPa)
E136B	58.94	88-336	29.07	-15.50
E137B	59.18	88-336	18.37	-10.90
E138B	61.52	88-336	32.09	-18.04
E139B	63.74	88-336	9.53	-5.61
E140B	64.30	88-336	33.25	-18.15
E141B	64.65	88-336	28.37	-15.08
E142B	12.15	88-337	13.20	-7.08
E143B	12.18	88-337	19.07	-10.83
E144B	14.85	88-337	26.05	-13.95
E145B	14.88	88-337	16.98	-9.50
E146B	14.91	88-337	10.23	-5.67
E147B	17.34	88-337	19.06	-10.76
E148B	17.47	88-337	24.19	-13.67
E149B	20.79	88-337	20.23	-11.70
E150B	24.02	88-337	24.88	-13.90
E151B	24.35	88-337	28.14	-15.42
E152B	24.39	88-337	26.28	-14.79
E153B	27.26	88-337	35.12	-19.67
E154B	27.43	88-337	27.21	-14.83
E155B	28.40	88-337	34.19	-19.15
E156B	28.43	88-337	23.95	-13.13
E157B	31.13	88-337	24.19	-13.89
E158B	31.40	88-337	27.44	-15.42
E159B	33.56	88-337	30.70	-16.91
E160B	33.90	88-337	24.88	-13.74
E161B	36.37	88-337	22.09	-12.64
E162B	36.51	88-337	22.79	-12.42
E163B	45.30	88-337	20.23	-11.19
E164B	45.41	88-337	25.12	-13.86
E165B	54.12	88-337	23.26	-13.58
E166B	54.43	88-337	16.28	-8.83
E167B	55.56	88-337	22.79	-12.76
E168B	55.60	88-337	13.26	-7.93
E169B	58.69	88-337	13.95	-7.47
E170B	61.06	88-337	18.60	-10.22
E171B	61.24	88-337	31.16	-16.99
E172B	64.23	88-337	16.98	-9.14
E173B	64.36	88-337	19.53	-10.58
E174B	64.58	88-337	20.70	-10.77

Table 3 - Uniaxial compressive test results

Sample Number	Borehole Number	Depth (m)	Qu (MPa)	ε_{peak} SR4A (%)	ε_{peak} LVDTs (%)	E SR4A (GPa)	E LVDTs (GPa)	ν Slope3 SR4A	ν Slope3 LVDTs	ν Slope2 SR4A	ν Slope2 LVDTs	ν Slope1 SR4A	ν Slope1 LVDTs
E01U	88-003	9.42	84.15	0.09	0.12	69.71	86.10	0.32	0.40	0.28	0.36	0.14	0.17
E03U	88-003	11.51	55.01	0.10	0.08	63.56	80.96	0.13	0.15	0.20	0.23	0.18	0.21
E05U	88-003	12.83	119.97	0.17	0.14	75.46	100.03	0.28	0.37	0.26	0.35	0.32	0.43
E07U	88-003	14.35	105.24	0.09	0.13	75.89	92.41	-	-	0.23	0.16	0.08	0.06
E09U	88-003	14.55	128.07	0.19	0.17	75.63	98.96	0.24	0.31	0.23	0.30	0.24	0.32
E11U	88-003	14.78	94.08	0.15	0.20	67.08	68.95	0.14	0.14	0.50	0.53	0.21	0.22
E13U	88-003	15.85	81.68	0.14	0.11	66.49	93.66	-	-	-	-	0.14	0.20
E15U	88-003	16.38	69.81	0.10	0.10	66.31	95.13	0.29	0.42	0.24	0.35	0.14	0.19
E17U	88-003	18.24	126.72	0.09	0.15	75.78	91.18	0.14	0.18	0.21	0.26	-	-
E19U	88-003	19.02	105.89	0.15	0.12	77.11	105.95	0.25	0.35	0.25	0.34	0.25	0.34
E21U	88-001	11.84	113.77	0.19	0.16	78.42	102.97	0.16	0.22	0.26	0.35	0.27	0.36
E23U	88-001	12.29	198.72	0.27	0.26	73.64	82.63	0.34	0.36	0.27	0.28	0.24	0.26
E25U	88-001	14.66	225.79	0.12	0.21	87.65	103.60	0.28	0.34	0.25	0.30	0.19	0.22
E27U	88-001	15.29	242.25	0.30	0.30	90.14	96.62	0.31	0.34	0.25	0.28	0.25	0.27
E29U	88-001	15.65	160.15	0.18	0.13	91.87	112.47	0.29	0.35	0.25	0.31	0.27	0.32
E31U	88-002	11.68	79.82	.16	0.20	85.21	78.02	-	-	0.43	0.39	0.23	0.27
E33U	88-002	12.80	139.35	0.14	0.13	104.01	123.47	0.26	0.36	0.27	0.32	0.22	0.26
E35U	88-002	13.51	224.34	0.28	0.25	86.35	88.25	0.32	0.33	0.28	0.29	0.26	0.27
E37U	88-002	14.17	97.43	0.10	0.10	101.70	101.40	0.32	0.32	0.33	0.33	0.34	0.34
E39U	88-002	14.83	216.46	0.25	0.25	92.56	101.48	0.31	0.34	0.28	0.30	0.19	0.21

Poisson's ratio:
Slope 1 Circumferential modulus calculated using secant at a circumferential extensometer displacement of 0.016 mm (using circumferential strain gauge readings).
Slope 2 Circumferential modulus calculated using secant at 0.50 Qu (using circumferential strain gauge readings).
Slope 3 Circumferential modulus calculated using tangent at 0.50 Qu (using circumferential strain gauge readings).
Young's modulus - calculated using readings from axial strain gauges and axial LVDTs at the tangent of 0.50 Qu.

Table 3 - Uniaxial compressive test results (cont'd)

Sample Number	Borehole Number	Depth (m)	Qu (MPa)	ε_{peak} SR4A (%)	ε_{peak} LVDTs (%)	E SR4A (GPa)	E LVDTs (GPa)	ν Slope3 SR4A	ν Slope3 LVDTs	ν Slope2 SR4A	ν Slope2 LVDTs	ν Slope1 SR4A	ν Slope1 LVDTs
E41U	88-001	16.84	136.03	0.17	0.15	84.74	93.20	0.30	0.33	0.26	0.29	0.27	0.29
E43U	88-001	18.31	60.93	0.11	0.09	75.80	78.32	0.30	0.31	0.28	0.29	0.29	0.30
E45U	88-001	19.28	116.54	0.18	0.19	69.31	84.58	0.28	0.35	0.28	0.35	0.30	0.38
E47U	88-002	10.41	101.82	-	0.20	-	86.94	-	-	0.49	0.32	0.44	0.29
E49U	88-002	15.98	87.85	0.16	0.19	57.00	67.77	0.26	0.31	0.22	0.26	0.23	0.27
E51U	88-002	16.23	85.67	0.15	0.15	62.43	77.61	0.28	0.35	0.25	0.31	0.14	0.18
E53U	88-002	16.79	56.67	0.08	0.13	66.74	65.52	0.29	0.28	0.30	0.29	0.30	0.29
E55U	88-003	20.07	138.12	0.20	0.19	72.88	90.70	0.27	0.34	0.29	0.36	0.22	0.27
E57U	88-335	5.40	326.69	0.40	0.31	84.86	90.35	0.28	0.29	0.26	0.28	0.34	0.38
E58U	88-335	12.32	188.97	0.24	0.18	82.05	97.11	0.26	0.31	0.25	0.29	0.25	0.30
E59U	88-335	14.28	163.38	0.21	0.15	82.00	102.94	0.23	0.29	0.23	0.29	0.23	0.29
E60U	88-335	26.20	170.68	0.20	0.23	83.04	102.20	0.24	0.29	0.25	0.31	0.24	0.29
E72U	88-335	34.34	231.01	0.23	0.19	101.70	119.61	0.30	0.36	0.25	0.29	0.25	0.30
E73U	88-335	41.33	286.21	0.30	0.21	100.33	117.48	0.33	0.38	0.28	0.33	0.27	0.31
E74U	88-335	45.71	304.81	0.40	0.29	83.30	93.51	0.32	0.35	0.28	0.32	0.28	0.31
E75U	88-335	52.01	77.67	0.12	0.06	71.61	111.08	0.26	-	0.29	-	0.29	-
E76U	88-335	56.16	50.14	0.08	-	65.54	-	0.36	-	0.31	-	-	-
E77U	88-335	59.14	123.16	0.18	0.09	75.51	111.22	0.29	0.42	0.30	0.44	0.30	0.44
E78U	88-335	62.48	102.01	0.16	0.13	73.54	93.62	0.34	0.43	0.29	0.37	0.33	0.43

Poisson's ratio:
Slope 1 Circumferential modulus calculated using secant at a circumferential extensometer displacement of 0.016 mm (using circumferential strain gauge readings).
Slope 2 Circumferential modulus calculated using secant at 0.50 Qu (using circumferential strain gauge readings).
Slope 3 Circumferential modulus calculated using tangent at 0.50 Qu (using circumferential strain gauge readings).
Young's modulus - calculated using readings from axial strain gauges and axial LVDTs at the tangent of 0.50 Qu.

Table 3 - Uniaxial compressive test results (cont'd)

Sample Number	Borehole Number	Depth (m)	Qu (MPa)	ε_{peak} SR4A (%)	ε_{peak} LVDTs (%)	E SR4A (GPa)	E LVDTs (GPa)	ν Slope3 SR4A	ν Slope3 LVDTs	ν Slope2 SR4A	ν Slope2 LVDTs	ν Slope1 SR4A	ν Slope1 LVDTs
E79U	88-336	21.06	166.92	-	0.26	66.57	115.34					0.20	0.17
E80U	88-336	25.98	112.38	0.18	0.13	73.16	95.38	0.21	0.28	0.23	0.29	0.22	0.28
E81U	88-336	31.28	114.23	0.16	0.14	85.77	119.80	0.19	0.27	0.24	0.33	0.24	0.33
E82U	88-336	36.36	153.01	0.22	0.20	79.30	105.05	0.27	0.35	0.22	0.29	0.22	0.30
E83U	88-336	40.39	215.97	0.18	0.19	68.49	91.07	0.18	0.14	0.20	0.16	0.19	0.16
E84U	88-336	41.63	258.41	0.32	0.26	87.33	99.12	0.28	0.32	0.24	0.28	0.24	0.27
E85U	88-336	47.56	289.73	0.33	0.33	86.75	86.70	0.28	0.28	0.29	0.29	0.27	0.27
E86U	88-336	51.22	237.23	0.31	0.27	79.58	83.18	0.29	0.30	0.25	0.26	-	-
E87U	88-336	56.95	376.74	0.48	0.40	81.83	85.32	0.28	0.30	0.24	0.25	0.21	0.22
E88U	88-336	59.00	335.23	0.43	0.35	83.16	88.57	0.29	0.31	0.24	0.25	0.21	0.22
E89U	88-336	61.65	179.91	0.22	0.27	63.83	81.29	-	-	0.16	0.20	0.16	0.20
E90U	88-336	63.80	157.54	0.24	0.17	72.85	91.64	0.44	0.56	0.26	0.33	0.22	0.28
E91U	88-336	64.37	236.48	0.30	0.26	77.31	85.69	0.24	0.27	0.19	0.21	0.25	0.28

Poisson's ratio:
Slope 1 Circumferential modulus calculated using secant at a circumferential extensometer displacement of 0.016 mm (using circumferential strain gauge readings).
Slope 2 Circumferential modulus calculated using secant at 0.50 Qu (using circumferential strain gauge readings).
Slope 3 Circumferential modulus calculated using tangent at 0.50 Qu (using circumferential strain gauge readings).
Young's modulus - calculated using readings from axial strain gauges and axial LVDTs at the tangent of 0.50 Qu.

Table 3 - Uniaxial compressive test results (cont'd)

Sample Number	Borehole Number	Depth (m)	Qu (MPa)	ε_{peak} SR4A (%)	ε_{peak} LVDTs (%)	E SR4A (GPa)	E LVDTs (GPa)	ν Slope3 SR4A	ν Slope3 LVDTs	ν Slope2 SR4A	ν Slope2 LVDTs	ν Slope1 SR4A	ν Slope1 LVDTs
E103U	88-337	12.43	157.18	0.22	0.15	68.49	92.64	0.29	0.39	0.24	0.32	0.21	0.28
E104U	88-337	15.24	109.99	0.16	0.08	71.54	128.02	0.32	-	0.29	-	0.31	-
E105U	88-337	17.40	235.21	0.36	0.24	69.97	91.55	0.30	0.39	0.24	0.31	0.19	0.25
E106U	88-337	20.70	102.15	0.14	0.12	79.33	138.05	0.31	-	0.21	0.36	0.21	0.36
E107U	88-337	24.29	147.47	0.17	0.10	81.98	121.53	0.27	0.41	0.24	0.35	0.22	0.33
E108U	88-337	27.32	239.46	0.24	0.17	91.43	129.91	0.28	0.40	0.24	0.34	0.21	0.30
E109U	88-337	28.20	163.65	0.18	0.12	-	89.04	-	-	-	-	-	0.31
E110U	88-337	31.20	254.84	0.28	0.17	97.77	132.94	0.29	0.40	0.28	0.38	0.30	0.41
E111U	88-337	33.97	197.37	0.22	0.20	84.97	97.80	-	-	-	-	0.26	0.30
E112U	88-337	36.44	92.31	0.14	0.09	76.24	123.29	0.29	-	0.31	-	0.30	-
E113U	88-337	45.19	82.57	0.13	0.07	59.12	113.29	0.30	-	0.25	-	0.25	-
E114U	88-337	54.21	64.12	0.10	0.11	93.81	63.87	0.34	0.23	0.29	0.19	0.36	0.24
E115U	88-337	55.75	141.37	0.10	0.17	77.47	110.95	0.29	0.41	0.26	0.37	0.26	0.38
E116U	88-337	58.81	69.04	0.10	0.13	26.50	67.14	-	-	-	-	-	0.48
E117U	88-337	60.95	41.72	0.07	0.07	55.64	59.60	-	-	-	-	0.21	0.22
E118U	88-337	64.30	66.21	0.10	0.04	77.91	165.07	0.25	-	0.29	-	-	-

Poisson's ratio:
Slope 1 Circumferential modulus calculated using secant at a circumferential extensometer displacement of 0.016 mm (using circumferential strain gauge readings).
Slope 2 Circumferential modulus calculated using secant at 0.50 Qu (using circumferential strain gauge readings).
Slope 3 Circumferential modulus calculated using tangent at 0.50 Qu (using circumferential strain gauge readings).
Young's modulus - calculated using readings from axial strain gauges and axial LVDTs at the tangent of 0.50 Qu.

Table 4 - Multi-stage triaxial test results

Sample Identification			σ_3=1.0 MPa		σ_3=2.0 MPa		σ_3=3.0 MPa		σ_3=4.0 MPa		σ_3=5.0 MPa		σ_3=10.0 MPa	
Sample Number	Borehole Number	Depth (m)	σ_1 (MPa)	ε_{peak} (%)	σ_1 (MPa)	ε_{peak} (%)	σ_1 (MPa)	ε_{peak} (%)	σ_1 (MPa)	ε_{peak} (%)	σ_1 (MPa)	ε_{peak} (%)	σ_1 (MPa)	ε_{peak} (%)
E02M	88-003	11.15	69.89	0.10	83.29	0.13	92.12	0.16	98.17	0.17	103.71	0.18	126.37	0.29
E04M	88-003	12.73	131.08	0.16	-	-	-	-	135.86	0.19	162.32	0.24	198.88	0.33
E06M	88-003	13.92	98.36	0.12	110.87	0.15	119.30	0.17	133.55	0.21	135.02	0.22	163.09	0.27
E08M	88-003	14.45	101.54	0.10	127.23	0.15	137.74	0.17	-	-	-	-	156.05	0.35
*E10M	88-003	14.68	128.49	0.18	141.27	0.20	142.49	0.20	-	-	-	-	161.70	0.32
E12M	88-003	14.99	96.71	0.11	100.36	0.12	104.00	0.13	108.87	0.14	114.78	0.16	139.20	0.24
E14M	88-003	16.00	103.82	0.15	117.37	0.20	126.43	0.22	129.19	0.30	136.44	0.32	167.59	0.48
E16M	88-003	17.70	47.88	0.10	56.56	0.12	65.34	0.14	68.38	0.15	79.94	0.19	115.56	0.33
E18M	88-003	18.41	39.66	0.08	43.66	0.10	57.54	0.16	62.14	0.17	70.65	0.21	94.08	0.27
E20M	88-003	19.20	161.01	0.18	171.16	0.21	178.31	0.22	182.52	0.24	187.69	0.25	209.98	0.30
E22M	88-001	11.94	149.29	0.19	-	-	-	-	-	-	-	-	177.83	0.36
E24M	88-001	12.39	203.52	0.26	213.92	0.32	216.69	0.33	-	-	-	-	-	-
E26M	88-001	15.19	268.48	0.33	278.60	0.35	282.14	0.36	284.91	0.37	287.33	0.38	307.31	0.42
E28M	88-001	15.49	273.15	0.34	282.06	0.36	284.13	0.36	285.69	0.37	287.94	0.38	313.54	0.42
E30M	88-002	11.02	183.82	0.17	284.53	0.36	-	-	-	-	-	-	-	-
E32M	88-002	12.55	299.19	0.35	312.23	0.37	-	-	-	-	-	-	-	-
*E34M	88-002	12.65	273.20	0.31	273.89	0.32	282.18	0.33	-	-	-	-	-	-
E36M	88-002	14.02	203.44	0.21	-	-	-	-	-	-	-	-	226.92	0.26
*E38M	88-002	14.68	94.72	0.07	157.84	0.15	173.99	0.17	-	-	-	-	-	-
E40M	88-001	16.74	161.14	0.24	180.86	0.33	-	-	-	-	-	-	-	-
E42M	88-001	18.06	167.34	0.24	172.78	0.26	-	-	175.54	0.28	181.33	0.29	196.70	0.34
E44M	88-001	18.49	65.59	0.08	76.89	0.11	80.60	0.11	84.92	0.12	90.35	0.13	112.19	0.17
E46M	88-001	19.61	129.50	0.18	-	-	132.87	0.20	-	-	135.98	0.22	150.50	0.25
E48M	88-002	15.85	114.91	0.15	117.33	0.16	-	-	-	-	-	-	132.83	0.34
E50M	88-002	16.10	79.54	0.13	84.83	0.14	88.82	0.15	87.61	0.15	88.48	0.16	102.01	0.18
E52M	88-002	16.64	78.54	0.17	86.32	0.19	-	-	-	-	90.30	0.24	106.56	0.28
*E54M	88-002	19.99	40.72	0.09	-	-	-	-	-	-	-	-	-	-
E56M	88-003	20.17	71.10	0.12	103.45	0.25	112.88	0.28	120.05	0.30	-	-	127.32	0.43
*E61M	88-335	5.60	173.33	0.13	-	-	-	-	-	-	-	-	-	-
*E62M	88-335	12.43	139.39	0.10	-	-	145.73	0.12	-	-	-	-	-	-
*E63M	88-335	17.42	217.32	0.18	235.48	0.21	274.55	0.26	-	-	-	-	-	-
*E64M	88-335	26.32	356.24	0.43	357.97	0.43	362.28	0.44	-	-	-	-	-	-

* indicates no residual data obtained due to violent failure

Table 4 - Multi-stage triaxial test results (cont'd)

Sample Identification			σ_3=2.0 MPa		σ_3=4.0 MPa		σ_3=6.0 MPa		σ_3=8.0 MPa		σ_3=10.0 MPa	
Sample Number	Borehole Number	Depth (m)	σ_1 (MPa)	ε_{peak} (%)	σ_1 (MPa)	ε_{peak} (%)	σ_1 (MPa)	ε_{peak} (%)	σ_1 (MPa)	ε_{peak} (%)	σ_1 (MPa)	ε_{peak} (%)
E65M	88-335	34.47	255.02	0.20	266.88	0.22	280.30	0.24	289.13	0.26	296.93	0.27
E66M	88-335	41.56	258.70	0.22	289.32	0.24	-	-	-	-	-	-
*E67M	88-335	45.84	175.02	0.20	186.02	0.23	-	-	-	-	-	-
E68M	88-335	59.44	80.98	0.10	84.22	0.11	-	-	-	-	99.38	0.16
*E69M	88-335	62.72	65.23	0.10	-	-	-	-	-	-	-	-
E70M	88-335	52.26	80.10	0.10	90.32	0.12	99.15	0.13	106.25	0.14	144.18	0.25
E71M	88-335	56.30	120.40	0.15	-	-	-	-	-	-	-	-
E92M	88-336	21.30	308.76	0.31	-	-	-	-	-	-	396.39	0.44
*E93M	88-336	26.08	119.28	0.11	136.58	0.13	155.72	0.15	166.91	0.16	183.34	0.20
*E94M	88-336	31.42	224.90	0.22	-	-	-	-	-	-	-	-
E95M	88-336	35.46	333.03	0.39	352.43	0.41	-	-	-	-	-	-
*E96M	88-336	40.49	297.04	0.22	-	-	-	-	-	-	333.76	0.27
E97M	88-336	41.90	289.54	0.25	-	-	-	-	-	-	315.18	0.29
*E98M	88-336	47.74	317.69	0.30	321.92	0.31	334.89	0.32	346.82	0.33	366.10	0.39
E99M	88-336	51.35	96.11	0.08	-	-	-	-	-	-	199.84	0.32
E100M	88-336	57.08	410.10	0.45	-	-	-	-	-	-	483.20	0.60
*E101M	88-336	59.10	384.58	0.42	397.83	0.44	410.38	0.46	420.85	0.47	437.50	0.50
E102M	88-336	64.50	217.26	0.24	229.90	0.26	233.19	0.28	241.07	0.30	257.87	0.32
E119M	88-337	12.33	144.36	0.14	-	-	-	-	-	-	161.83	0.19
*E120M	88-337	15.14	97.48	0.10	-	-	-	-	105.52	0.13	122.56	0.13
*E121M	88-337	17.54	115.32	0.10	139.15	0.14	158.47	0.35	-	-	-	-
E122M	88-337	20.85	133.27	0.09	-	-	144.44	0.08	-	-	198.73	0.26
*E123M	88-337	24.45	137.79	0.14	156.99	0.16	171.86	0.18	185.53	0.20	249.45	0.35
E124M	88-337	27.49	222.38	0.19	249.10	0.21	277.04	0.25	297.54	0.28	313.89	0.30
E125M	88-337	28.30	174.10	0.14	197.01	0.15	212.83	0.17	229.69	0.20	277.49	0.32
E126M	88-337	31.33	306.02	0.27	317.43	0.24	-	-	324.70	0.28	346.58	0.34
E127M	88-337	33.63	156.12	0.13	175.66	0.15	196.75	0.18	214.13	0.20	284.66	0.45
E128M	88-337	36.56	49.73	0.04	69.63	0.06	80.87	0.07	-	-	127.93	0.29
E129M	88-337	54.36	84.00	0.08	100.54	0.10	116.31	0.12	132.93	0.14	187.73	0.25
E130M	88-337	55.92	42.90	0.10	52.04	0.12	61.34	0.14	69.87	0.15	127.76	0.45
E131M	88-337	58.94	46.02	0.07	58.80	0.10	71.50	0.12	75.55	0.14	135.65	0.49
*E132M	88-337	61.17	216.50	0.24	233.56	0.25	236.58	0.26	248.46	0.29	262.59	0.32
E133M	88-337	64.42	154.12	0.16	163.38	0.20	171.69	0.21	185.58	0.23	-	-

* indicates no residual data obtained due to violent failure

APPENDIX A

STRESS-STRAIN CURVES OF UNIAXIAL TESTS USING AXIAL LVDTs

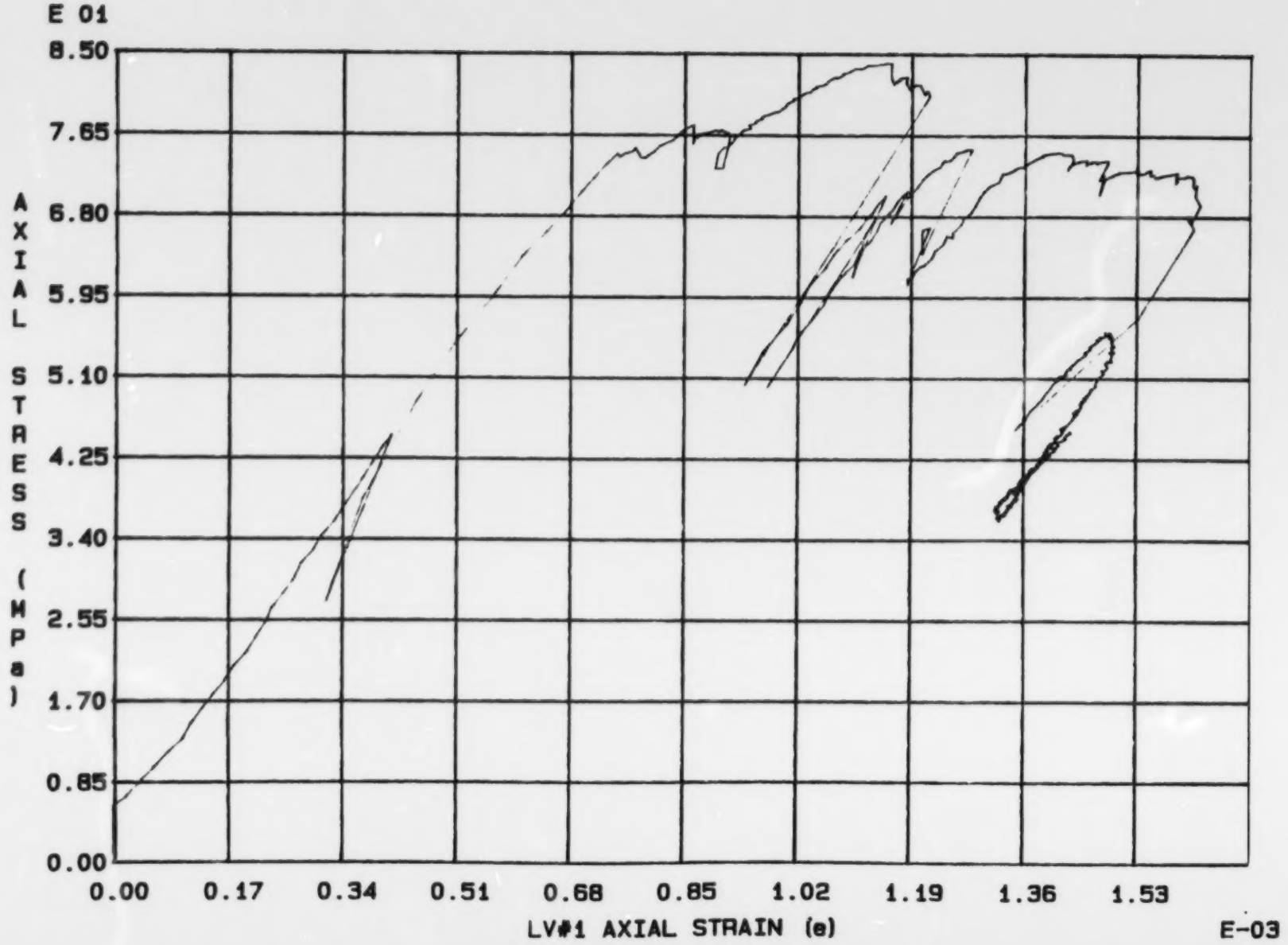

E 01
8.50
7.65
6.80
5.95
5.10
4.25
3.40
2.55
1.70
0.85
0.00
AXIAL STRESS (MPa)
0.00
0.17
0.34
0.51
0.68
0.85
1.02
1.19
1.36
1.53
LV#1 AXIAL STRAIN (e)
E-03

Fig. A-1 E1U

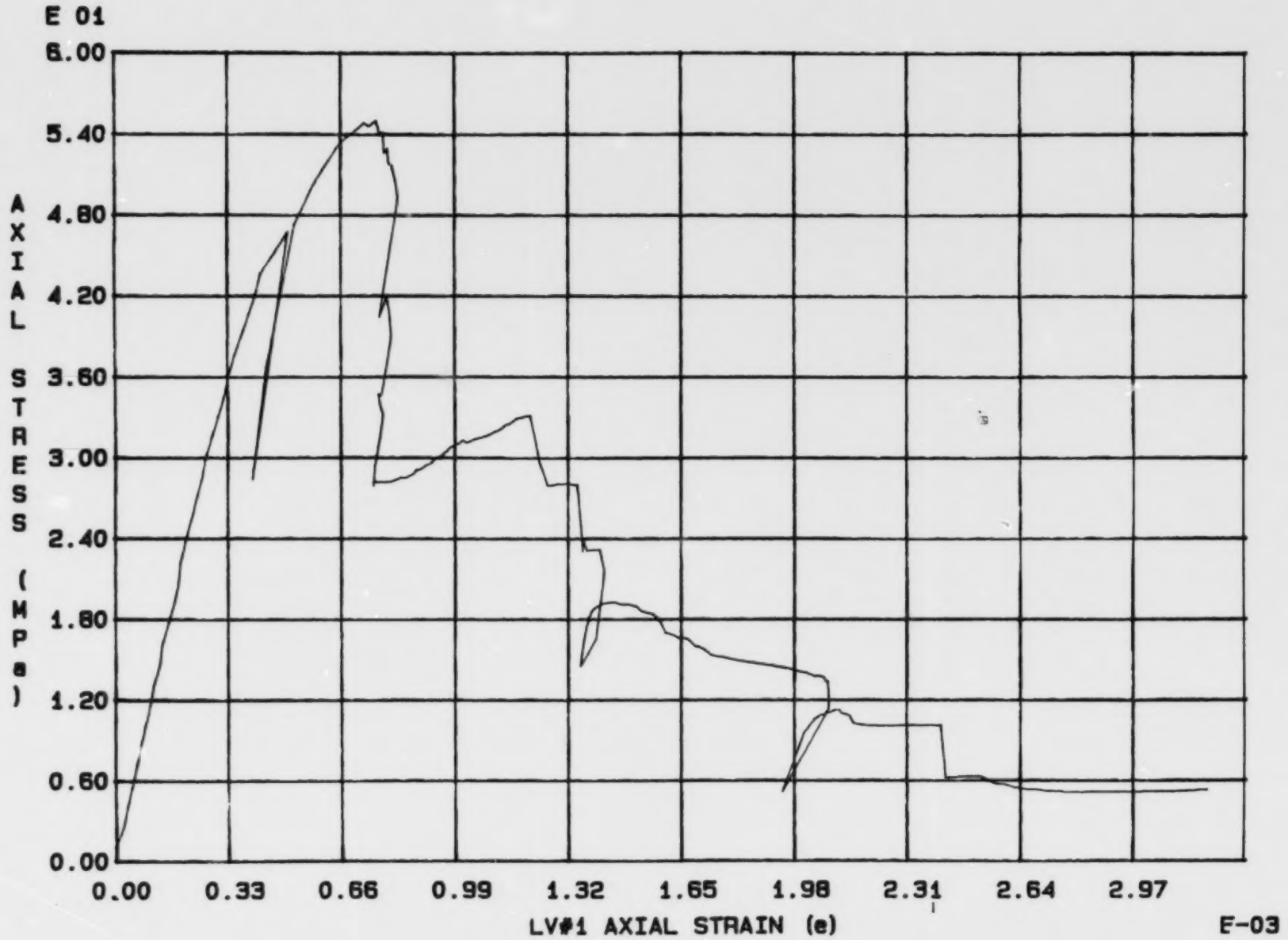

E 01
6.00
5.40
4.80
4.20
3.60
3.00
2.40
1.80
1.20
0.60
0.00
AXIAL STRESS (MPa)
0.00
0.33
0.66
0.99
1.32
1.65
1.98
2.31
2.64
2.97
LV#1 AXIAL STRAIN (e)
E-03

Fig. A-2 E3U

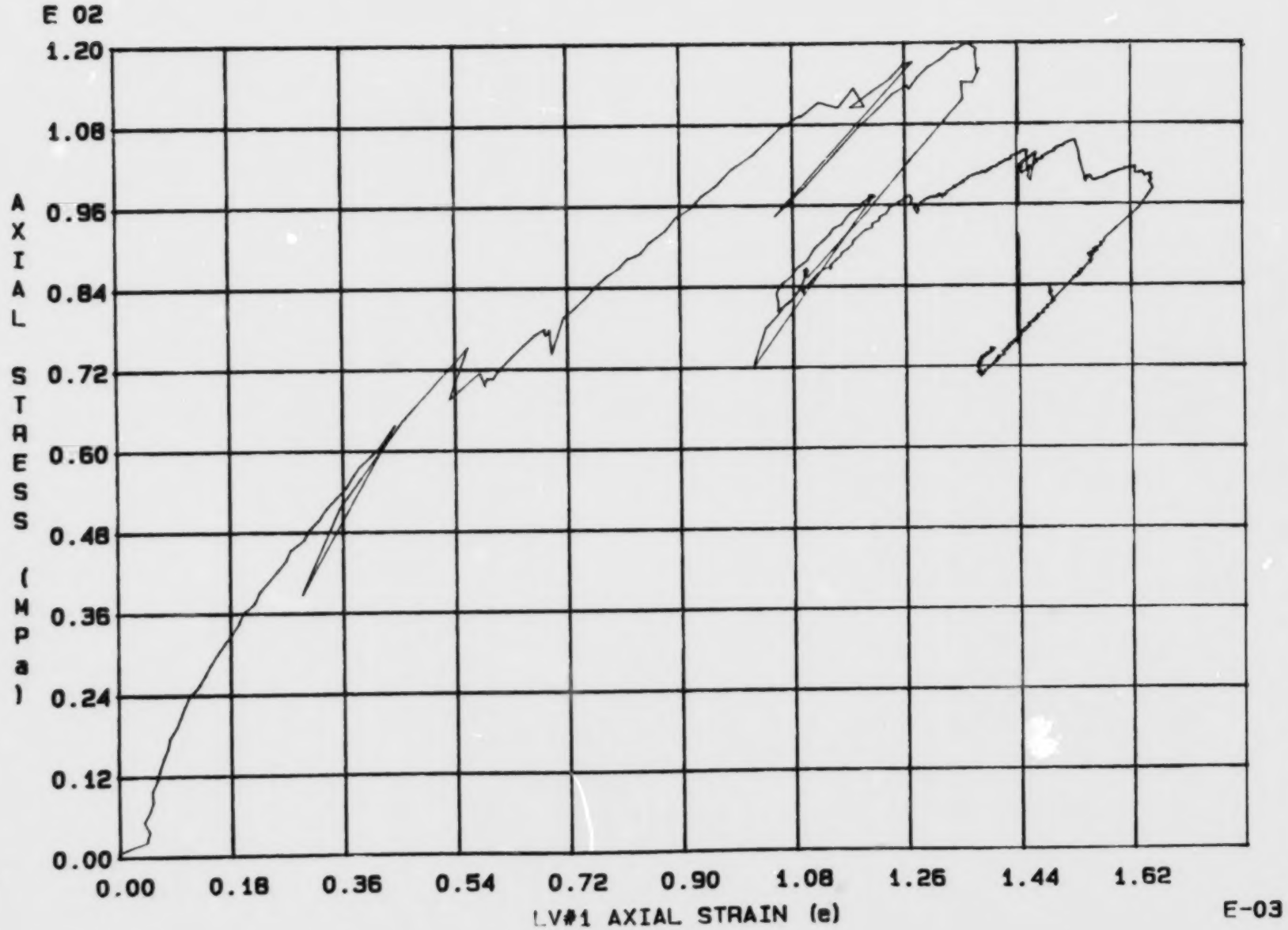

E 02
1.20
1.08
0.96
0.84
0.72
0.60
0.48
0.36
0.24
0.12
0.00
AXIAL STRESS (MPa)
0.00
0.18
0.36
0.54
0.72
0.90
1.08
1.26
1.44
1.62
LV#1 AXIAL STRAIN (e)
E-03

Fig. A-3 E5U

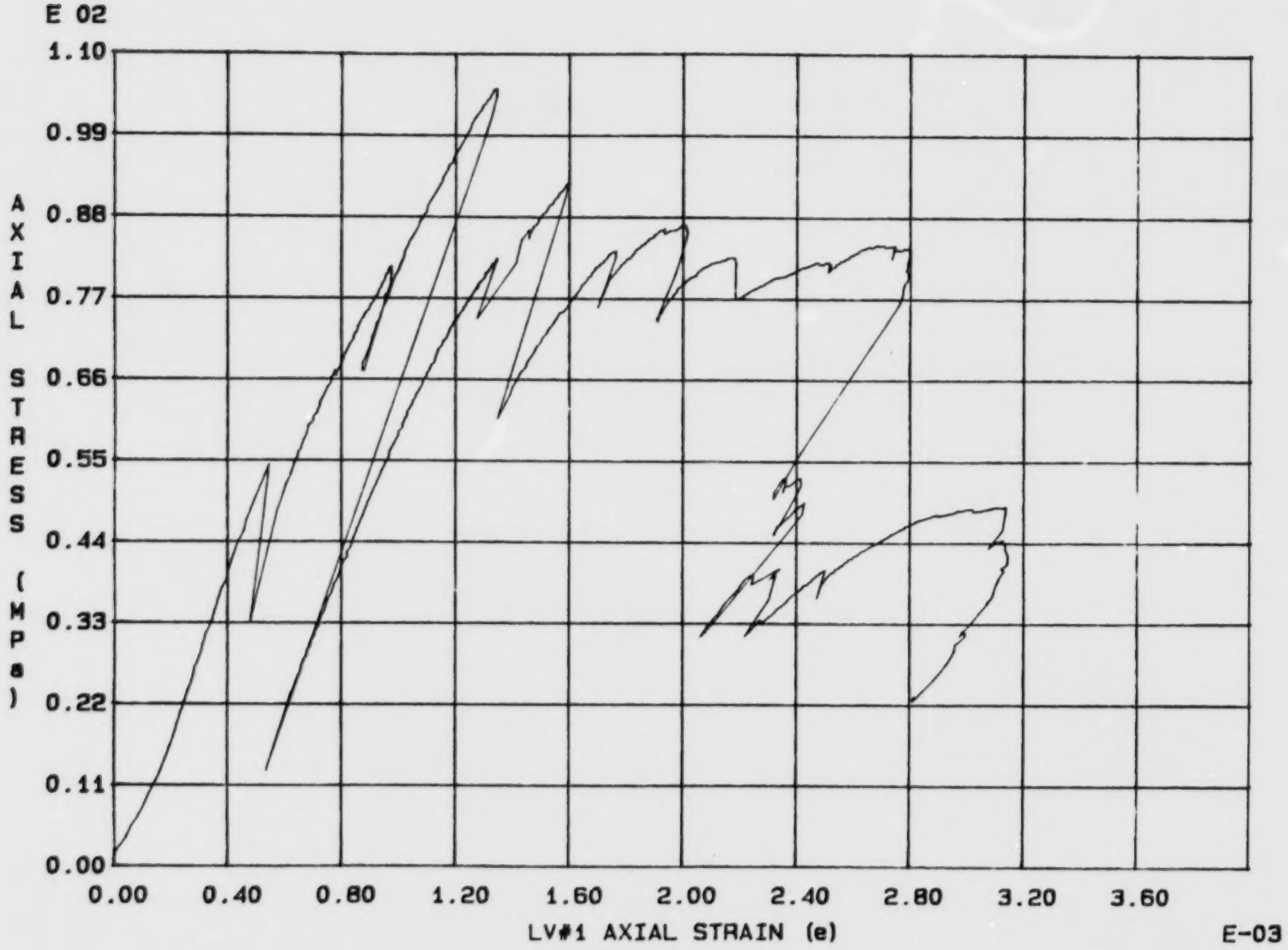

E 02
1.10
0.99
0.88
0.77
0.66
0.55
0.44
0.33
0.22
0.11
0.00
AXIAL STRESS (MPa)
0.00
0.40
0.80
1.20
1.60
2.00
2.40
2.80
3.20
3.60
LV#1 AXIAL STRAIN (e)
E-03

Fig. A-4 E7U

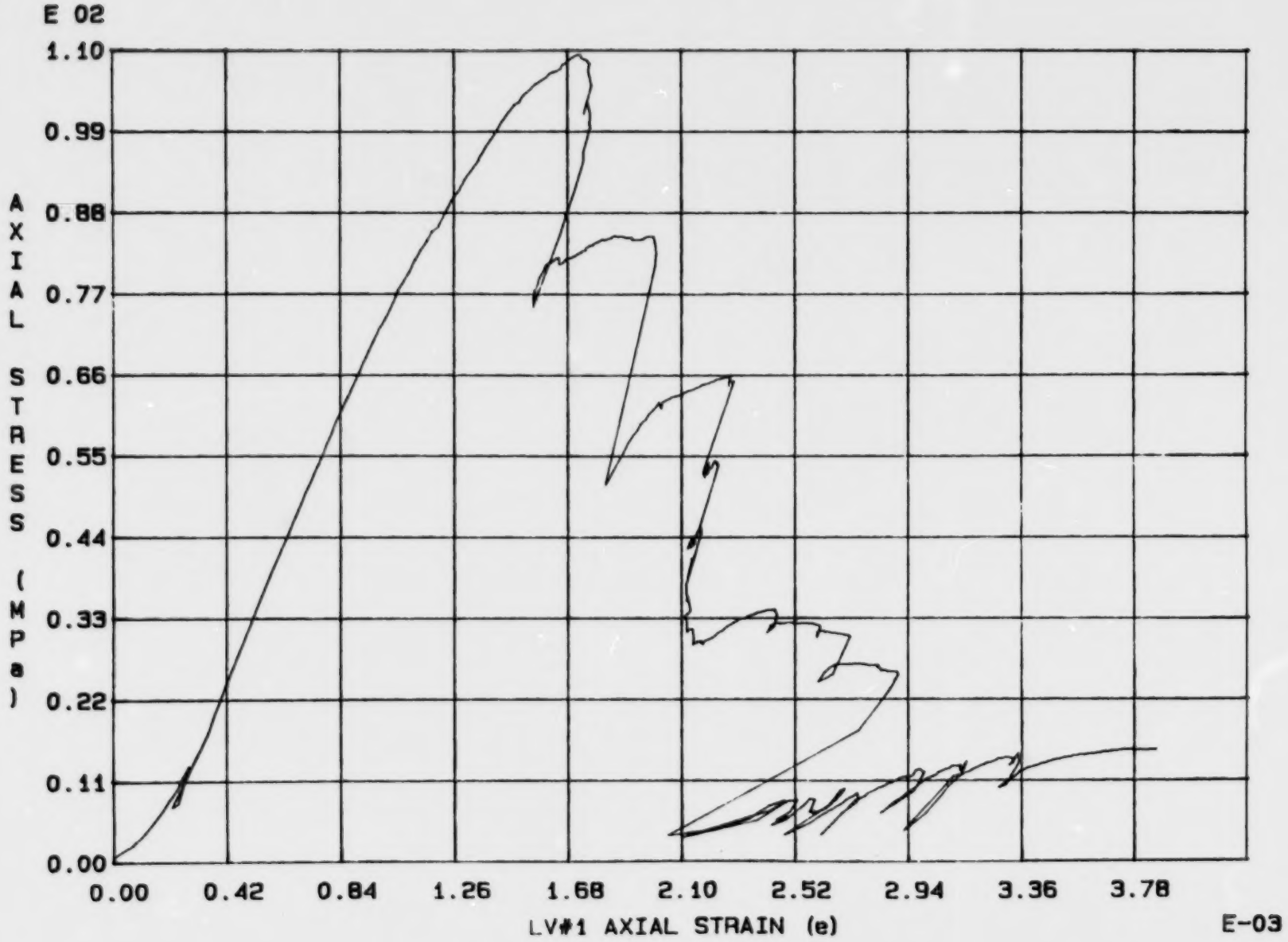

E 02
1.10
0.99
0.88
0.77
0.66
0.55
0.44
0.33
0.22
0.11
0.00
AXIAL STRESS (MPa)
0.00
0.42
0.84
1.26
1.68
2.10
2.52
2.94
3.36
3.78
LV#1 AXIAL STRAIN (e)
E-03

Fig. A-5 E9UA

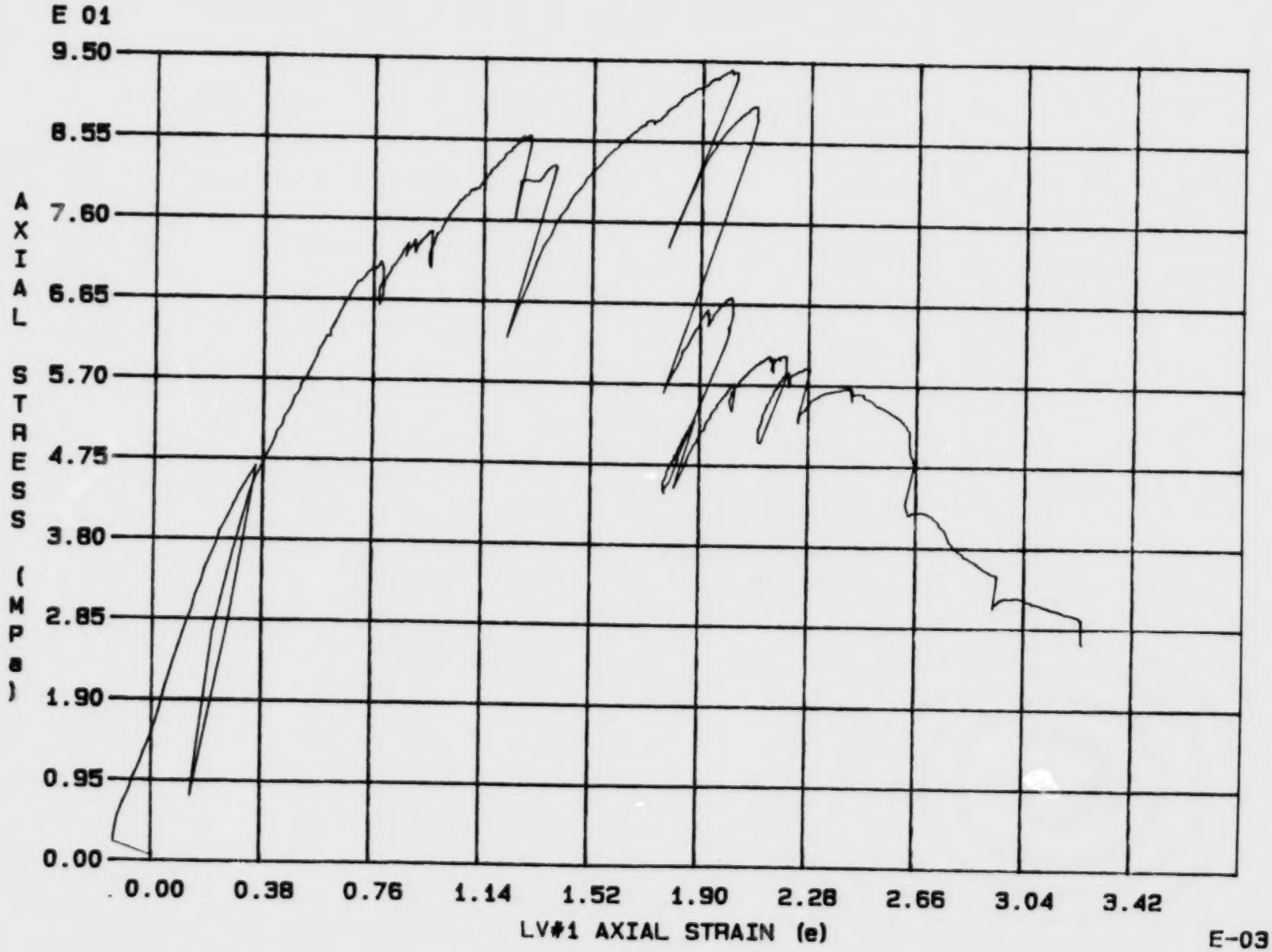

E 01
9.50
8.55
7.60
6.65
5.70
4.75
3.80
2.85
1.90
0.95
0.00
AXIAL STRESS (MPa)
0.00
0.38
0.76
1.14
1.52
1.90
2.28
2.66
3.04
3.42
LV#1 AXIAL STRAIN (e)
E-03

Fig. A-6 E11U

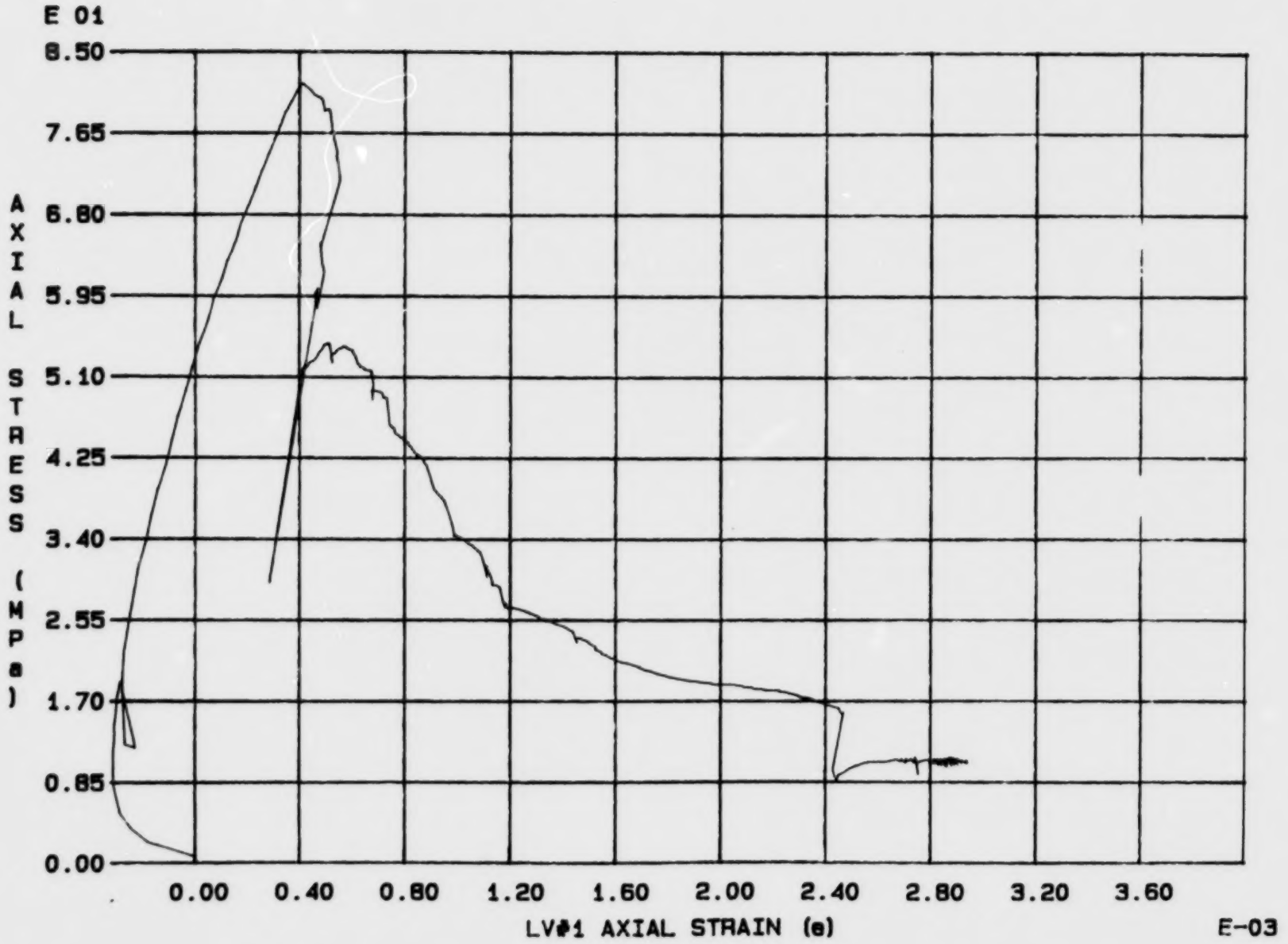

E 01
8.50
7.65
6.80
5.95
5.10
4.25
3.40
2.55
1.70
0.85
0.00
AXIAL STRESS (MPa)
0.00
0.40
0.80
1.20
1.60
2.00
2.40
2.80
3.20
3.60
LV#1 AXIAL STRAIN (e)
E-03

Fig. A-7 E13U

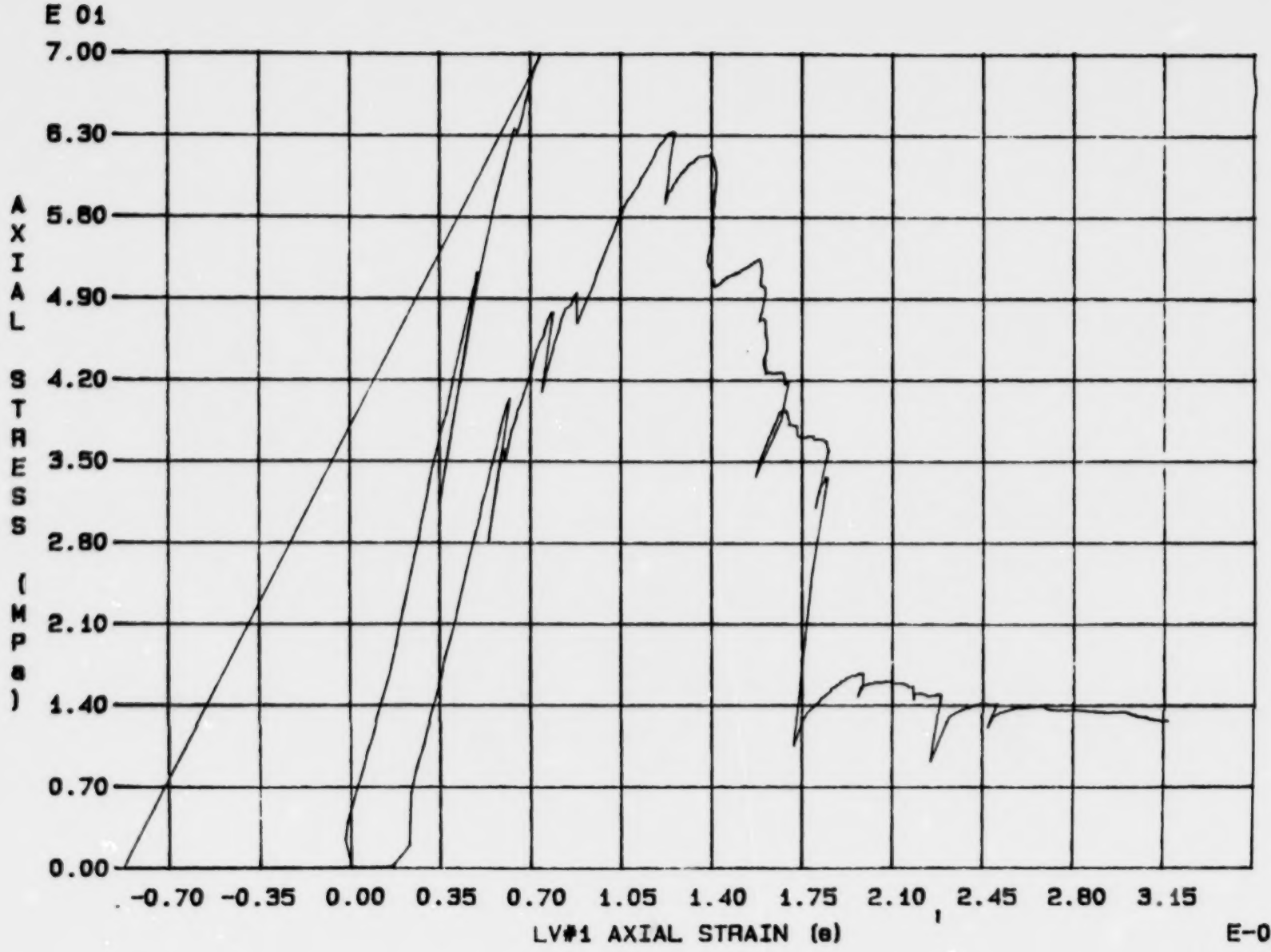

E 01
7.00
6.30
5.60
4.90
4.20
3.50
2.80
2.10
1.40
0.70
0.00
AXIAL STRESS (MPa)
-0.70 -0.35 0.00 0.35 0.70 1.05 1.40 1.75 2.10 2.45 2.80 3.15
LV#1 AXIAL STRAIN (e)
E-03

Fig. A-8 E15U

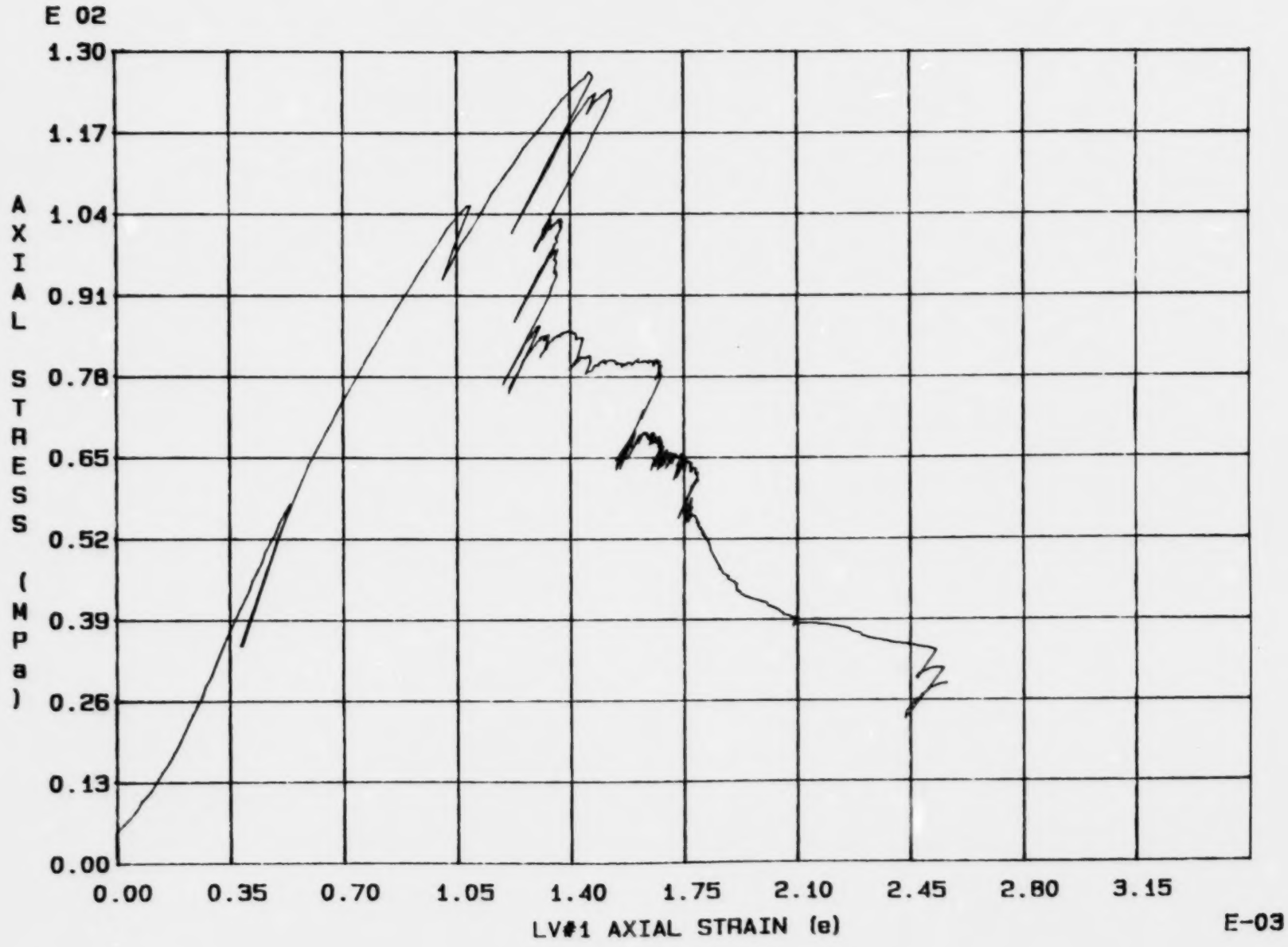

E 02
1.30
1.17
1.04
0.91
0.78
0.65
0.52
0.39
0.26
0.13
0.00
AXIAL STRESS (MPa)
0.00
0.35
0.70
1.05
1.40
1.75
2.10
2.45
2.80
3.15
LV#1 AXIAL STRAIN (e)
E-03

Fig. A-9 E17U

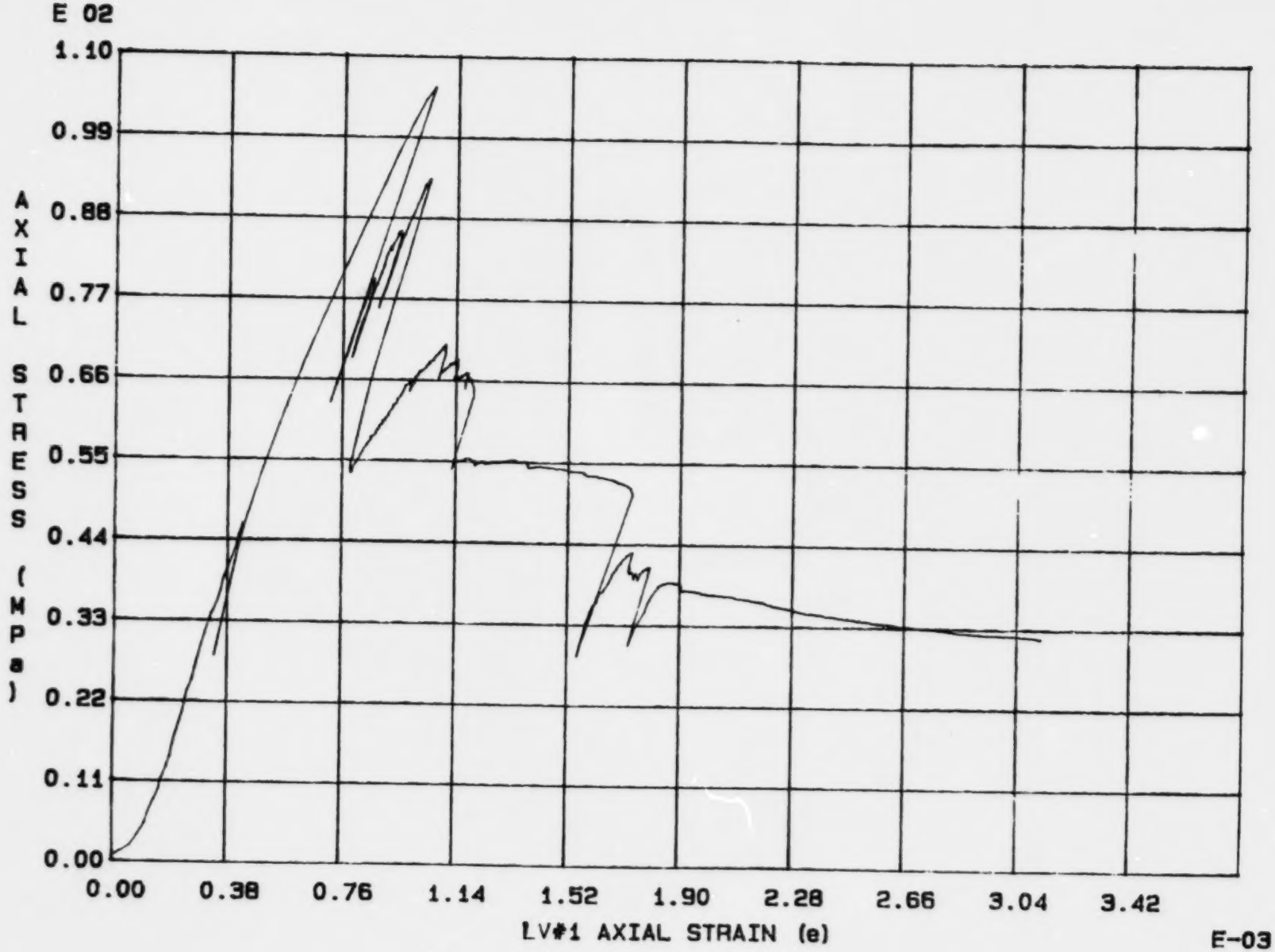

E 02
1.10
0.99
0.88
0.77
0.66
0.55
0.44
0.33
0.22
0.11
0.00
AXIAL STRESS (MPa)
0.00
0.38
0.76
1.14
1.52
1.90
2.28
2.66
3.04
3.42
LV#1 AXIAL STRAIN (e)
E-03

Fig. A-10 E19U

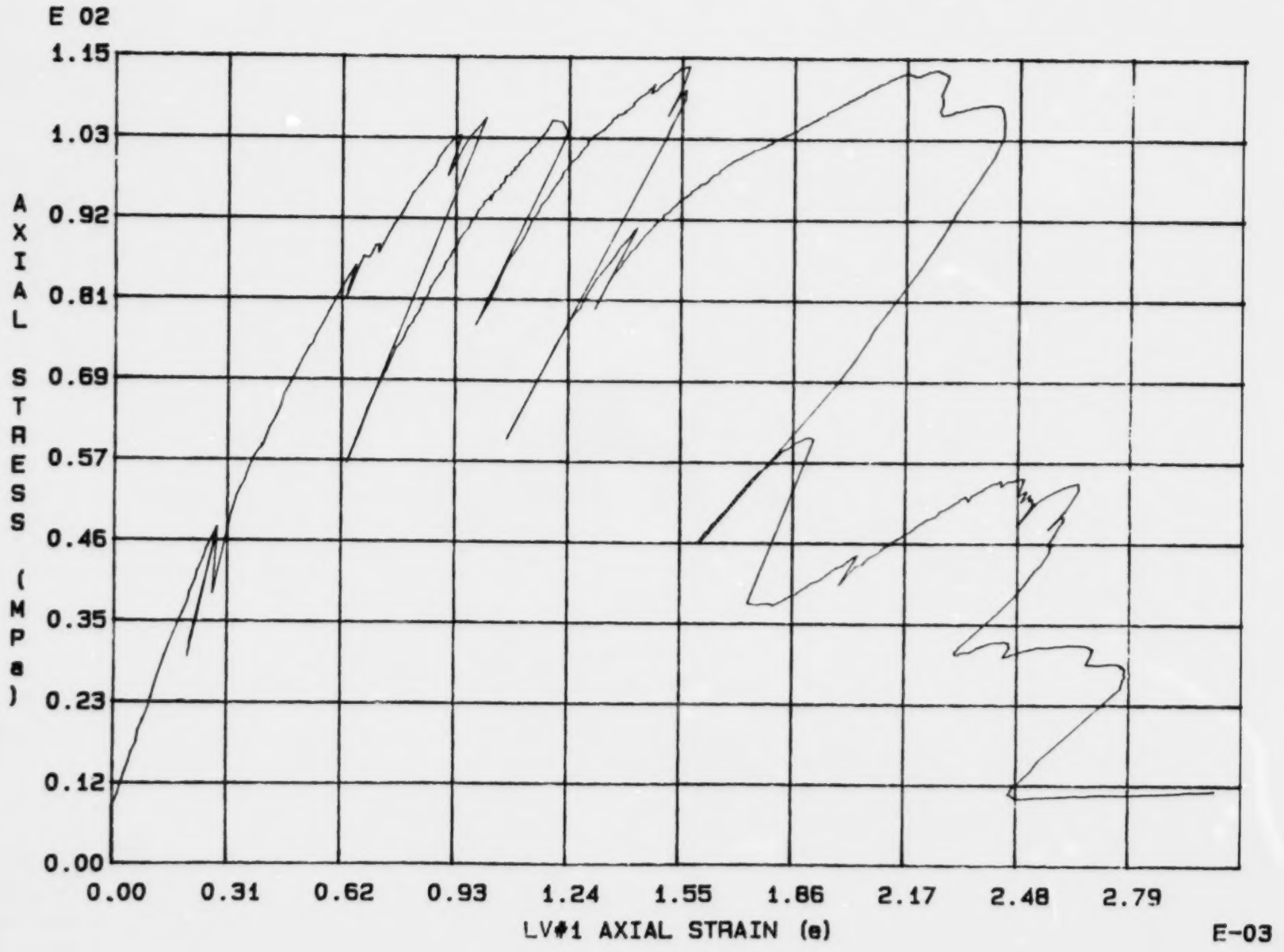

E 02
1.15
1.03
0.92
0.81
0.69
0.57
0.46
0.35
0.23
0.12
0.00
AXIAL STRESS (MPa)
0.00
0.31
0.62
0.93
1.24
1.55
1.86
2.17
2.48
2.79
LV#1 AXIAL STRAIN (e)
E-03

Fig. A-11 E21U

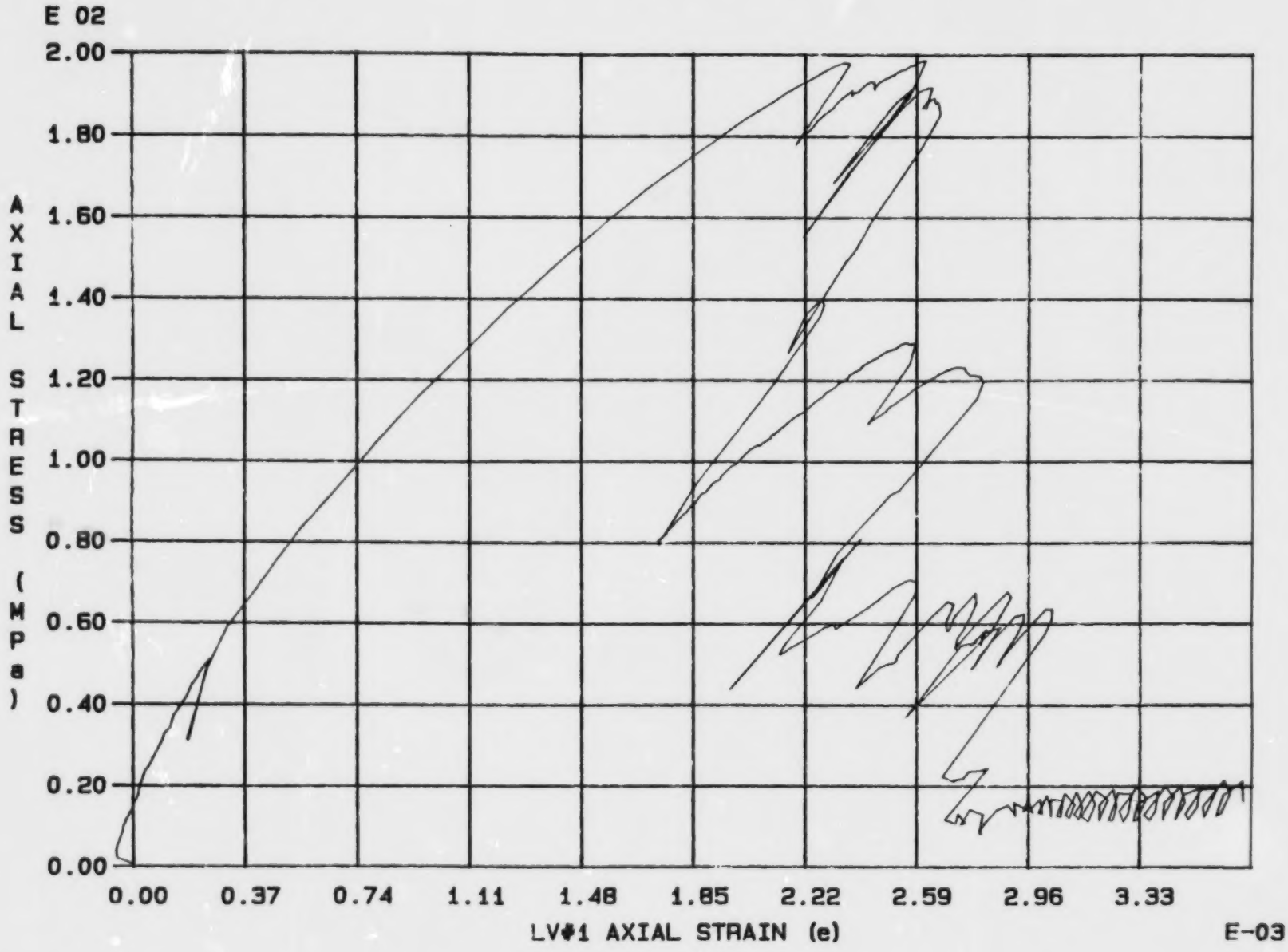

E 02
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
AXIAL STRESS (MPa)
0.00
0.37
0.74
1.11
1.48
1.85
2.22
2.59
2.96
3.33
LV#1 AXIAL STRAIN (e)
E-03

Fig. A-12 E23U

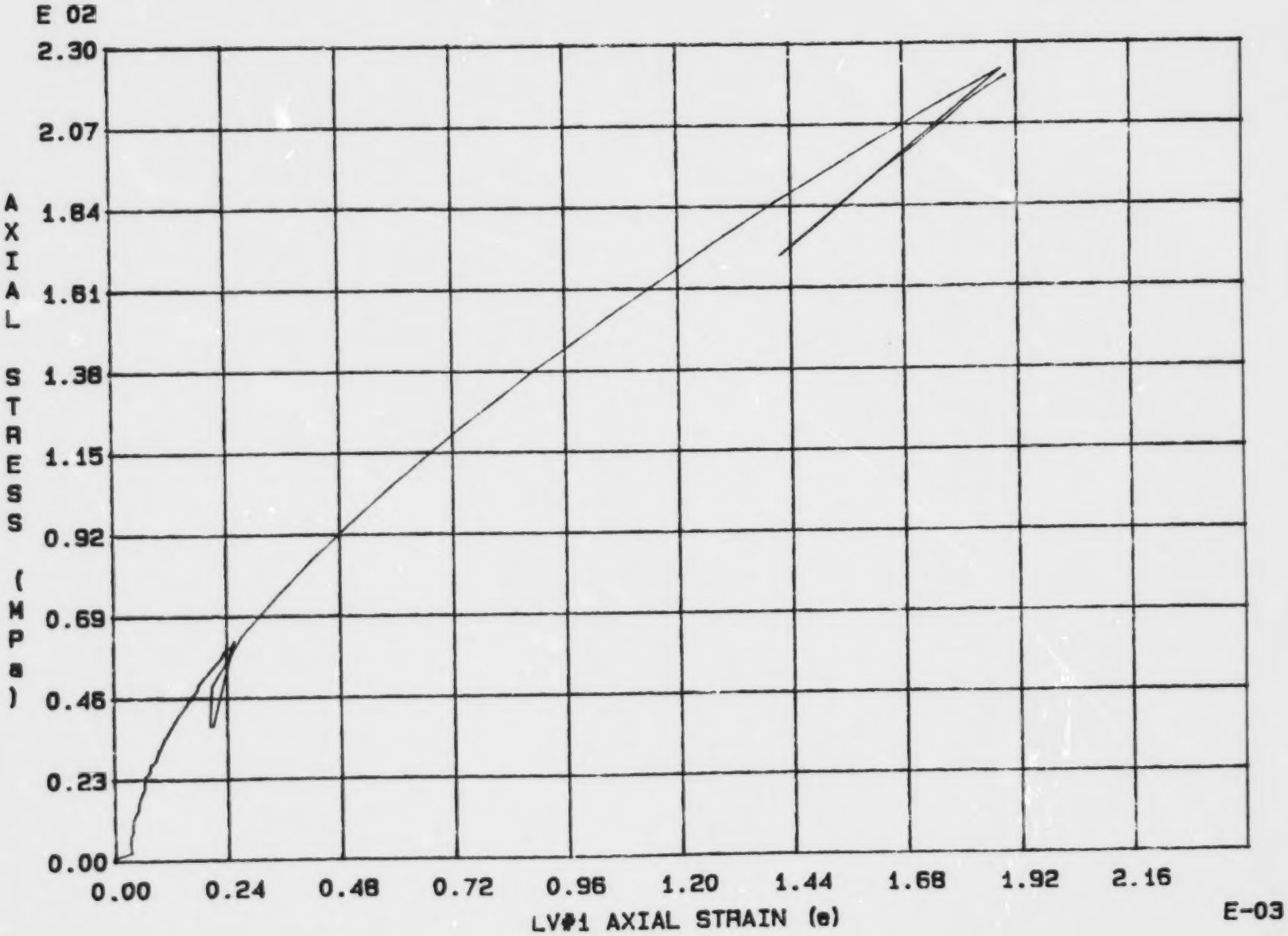

E 02
2.30
2.07
1.84
1.61
1.38
1.15
0.92
0.69
0.46
0.23
0.00
AXIAL STRESS (MPa)
0.00
0.24
0.48
0.72
0.96
1.20
1.44
1.68
1.92
2.16
E-03
LV#1 AXIAL STRAIN (e)

Fig. A-13 E25U

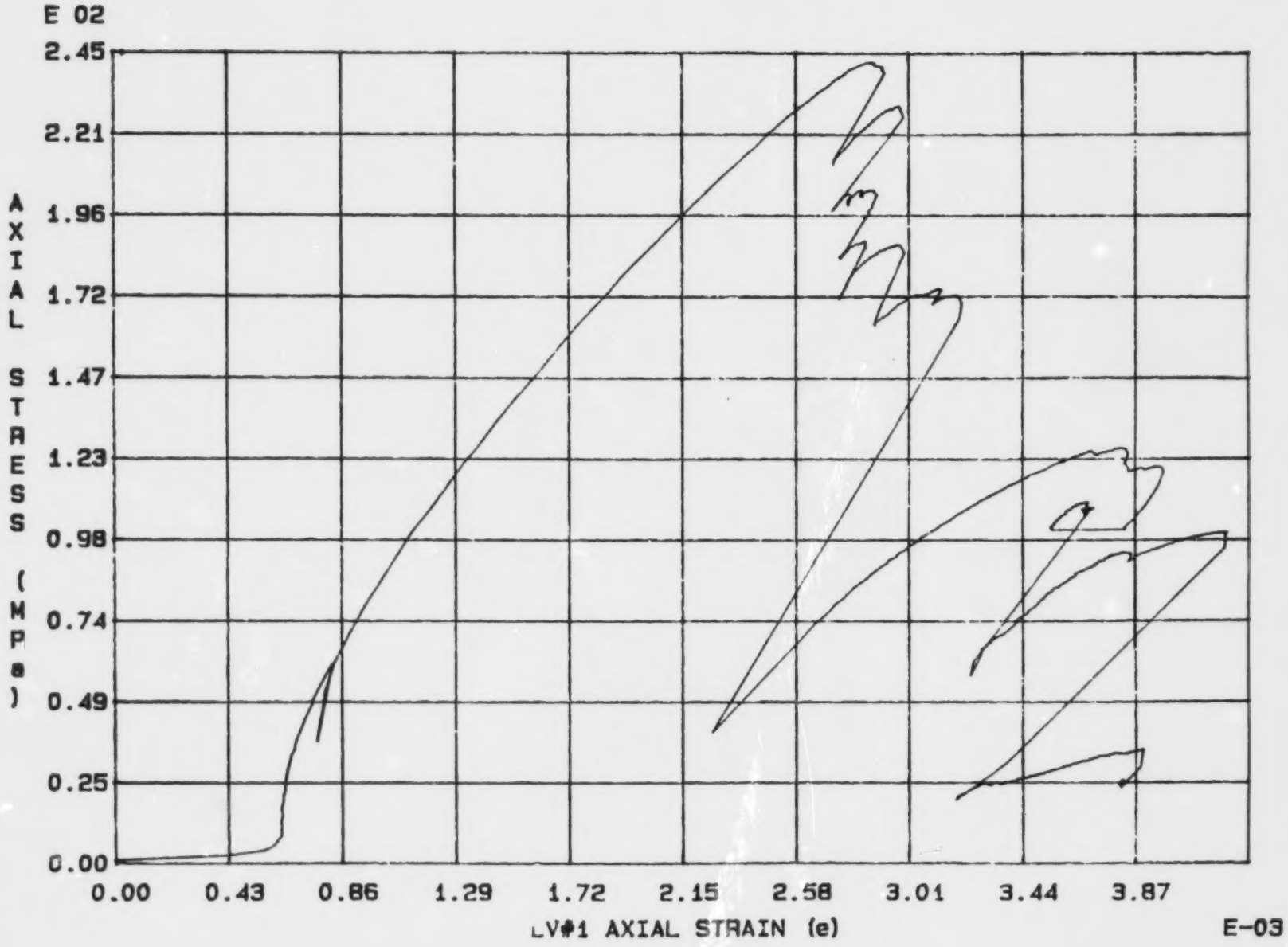

E 02
2.45
2.21
1.96
1.72
1.47
1.23
0.98
0.74
0.49
0.25
0.00
AXIAL STRESS (MPa)
0.00
0.43
0.86
1.29
1.72
2.15
2.58
3.01
3.44
3.87
LV#1 AXIAL STRAIN (e)
E-03

Fig. A-14 E27U

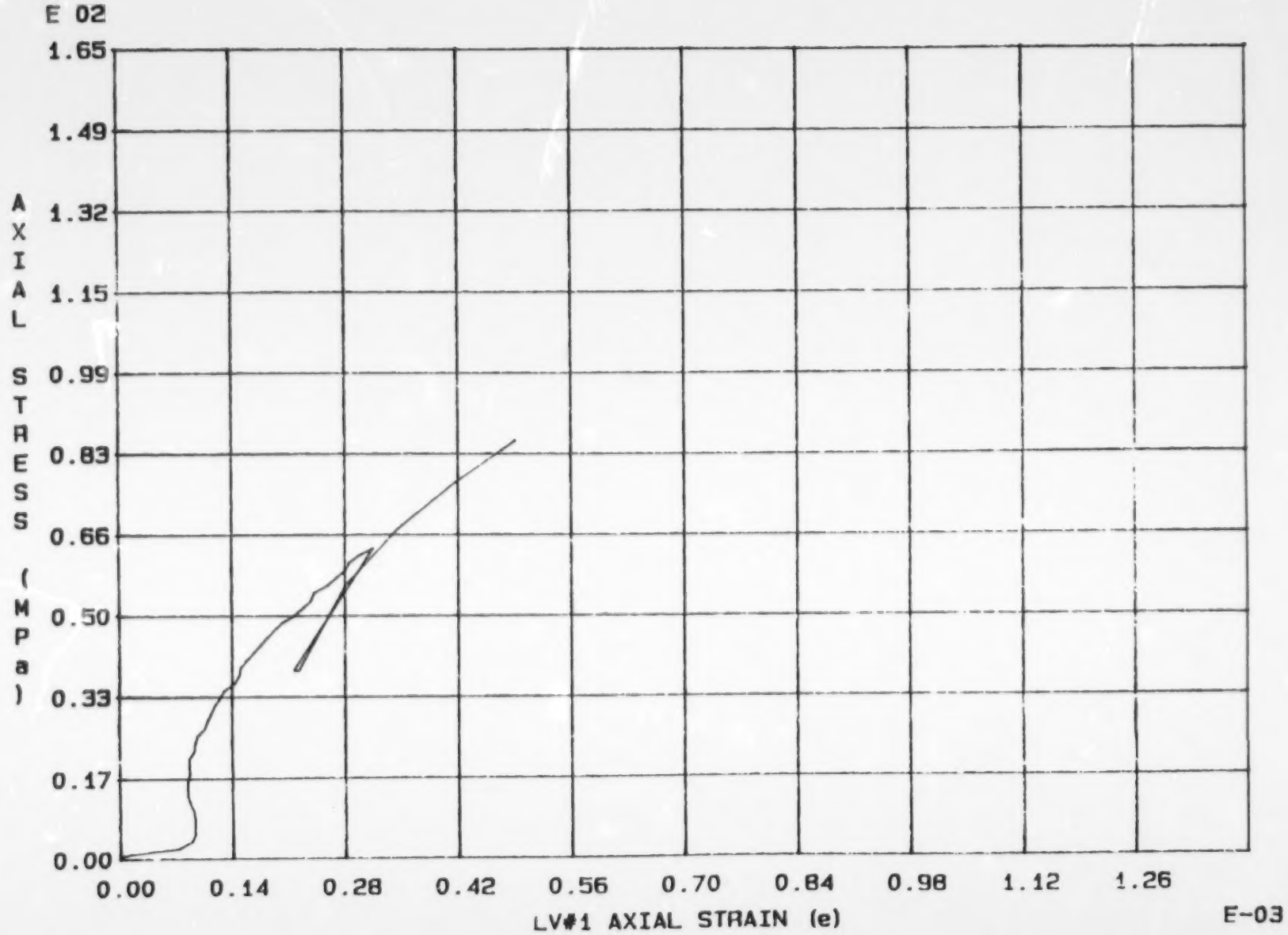

E 02
1.65
1.49
1.32
1.15
0.99
0.83
0.66
0.50
0.33
0.17
0.00
AXIAL STRESS (MPa)
0.00
0.14
0.28
0.42
0.56
0.70
0.84
0.98
1.12
1.26
LV#1 AXIAL STRAIN (e)
E-03

Fig. A-15 E29U

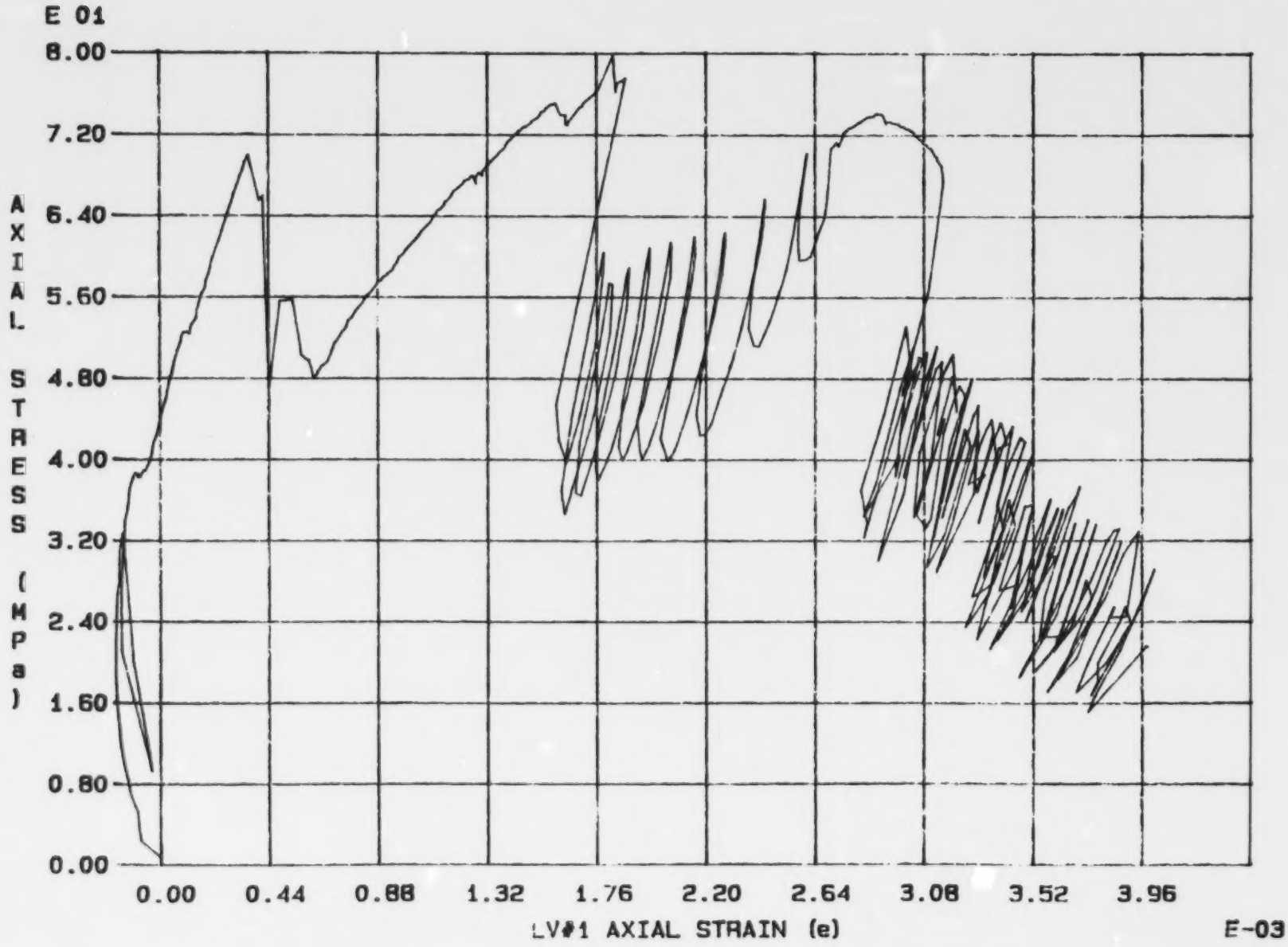

E 01
8.00
7.20
6.40
5.60
4.80
4.00
3.20
2.40
1.60
0.80
0.00
AXIAL STRESS (MPa)
0.00
0.44
0.88
1.32
1.76
2.20
2.64
3.08
3.52
3.96
LV#1 AXIAL STRAIN (e)
E-03

Fig. A-16 E31U

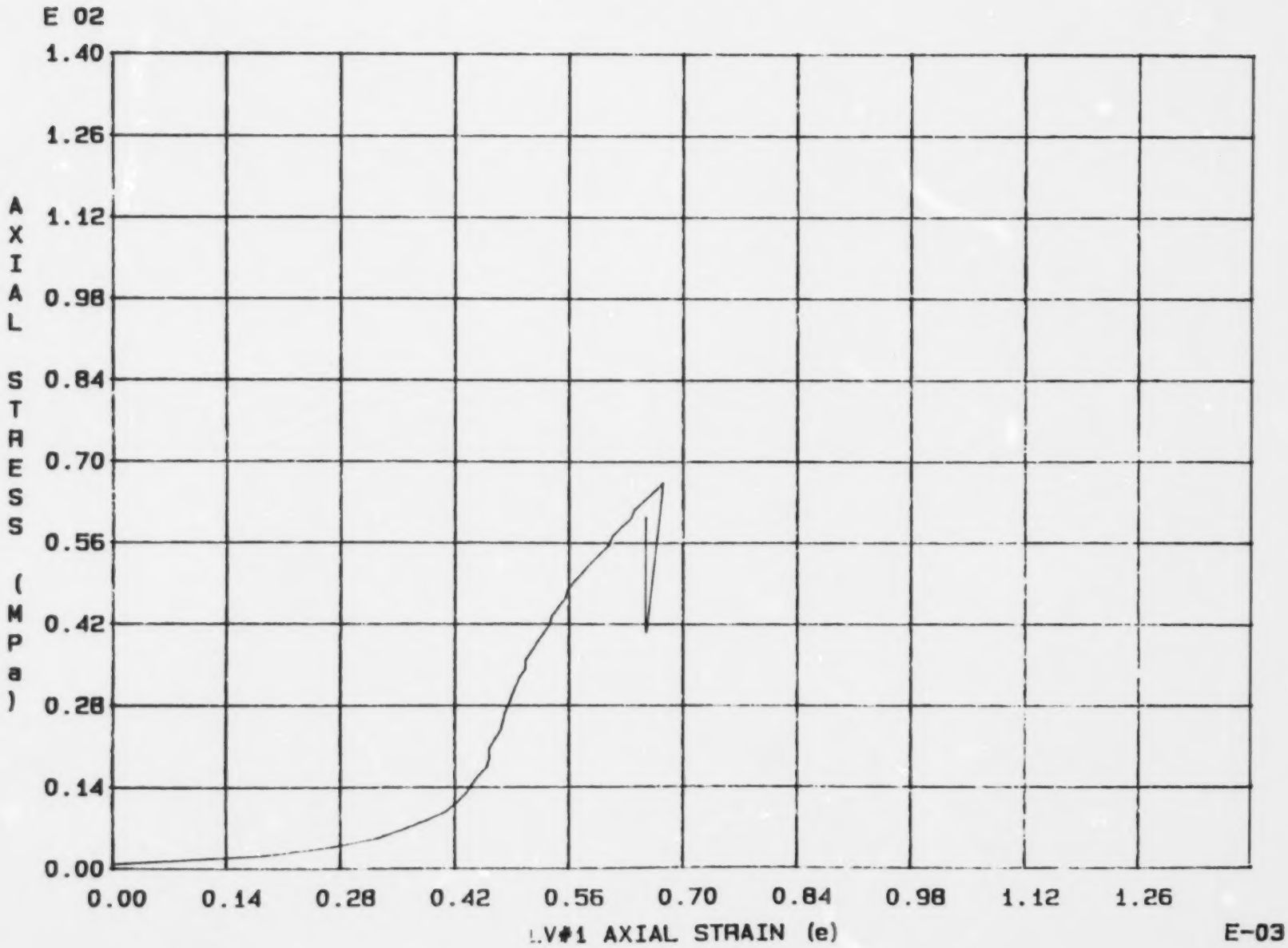

E 02
1.40
1.26
1.12
0.98
0.84
0.70
0.56
0.42
0.28
0.14
0.00
AXIAL STRESS (MPa)
0.00
0.14
0.28
0.42
0.56
0.70
0.84
0.98
1.12
1.26
LVDT#1 AXIAL STRAIN (e)
E-03

Fig. A-17 E33U

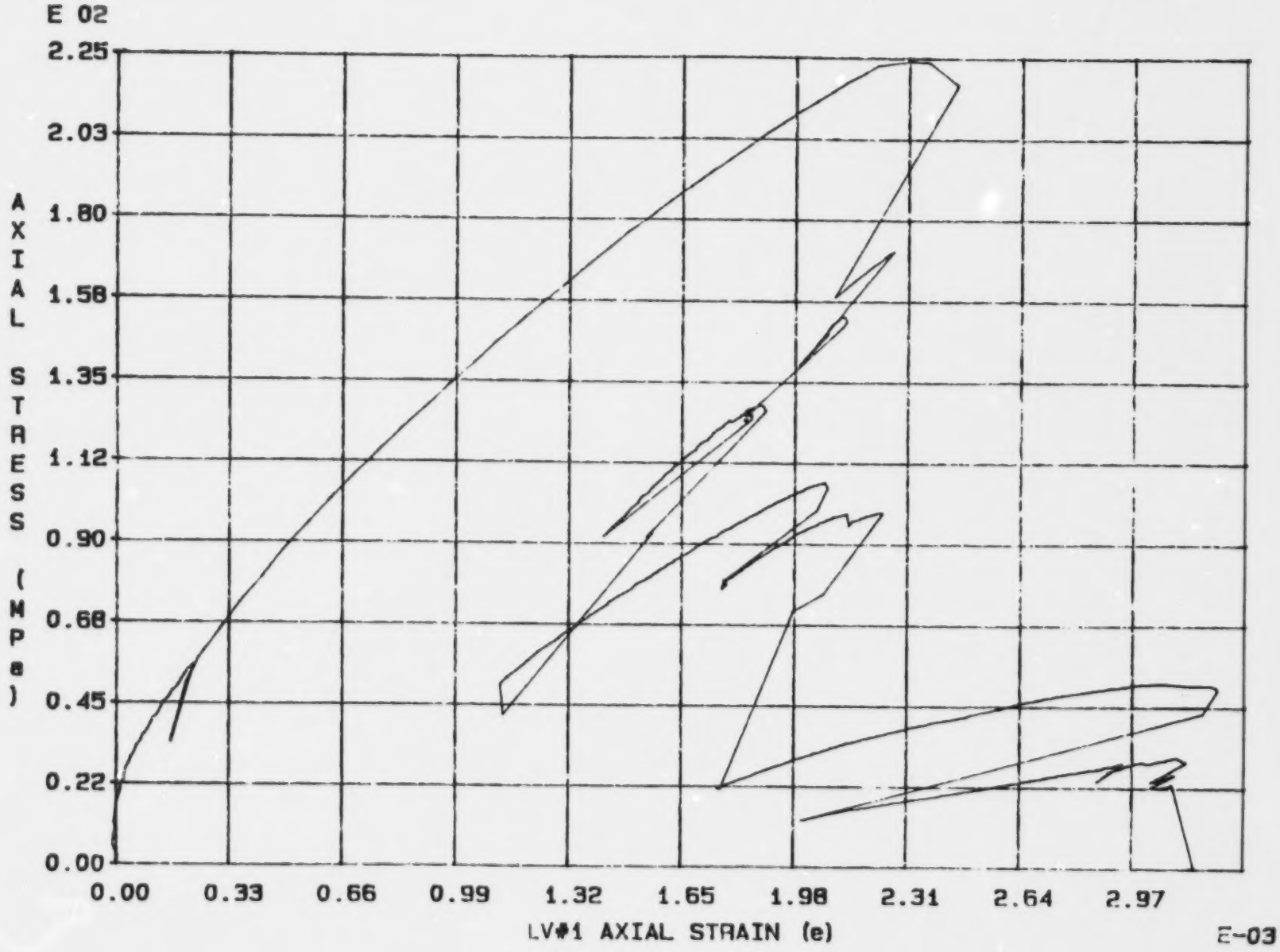

E 02
2.25
2.03
1.80
1.58
1.35
1.12
0.90
0.68
0.45
0.22
0.00
AXIAL STRESS (MPa)
0.00
0.33
0.66
0.99
1.32
1.65
1.98
2.31
2.64
2.97
LV#1 AXIAL STRAIN (e)
E-03

Fig. A-18 F35U

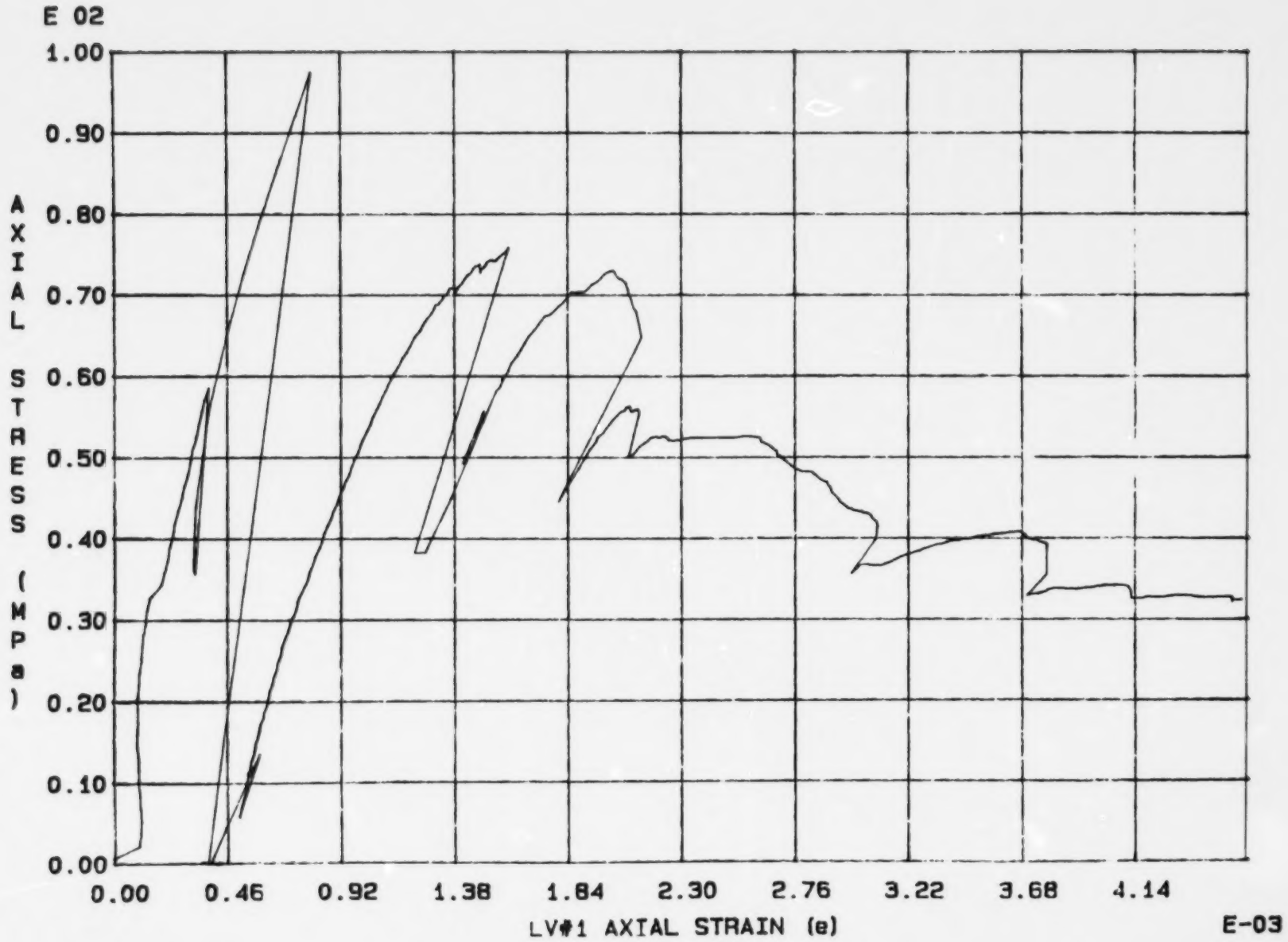

E 02
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
AXIAL STRESS (MPa)
0.00
0.46
0.92
1.38
1.84
2.30
2.76
3.22
3.68
4.14
LV#1 AXIAL STRAIN (e)
E-03

Fig. A-19 E37U

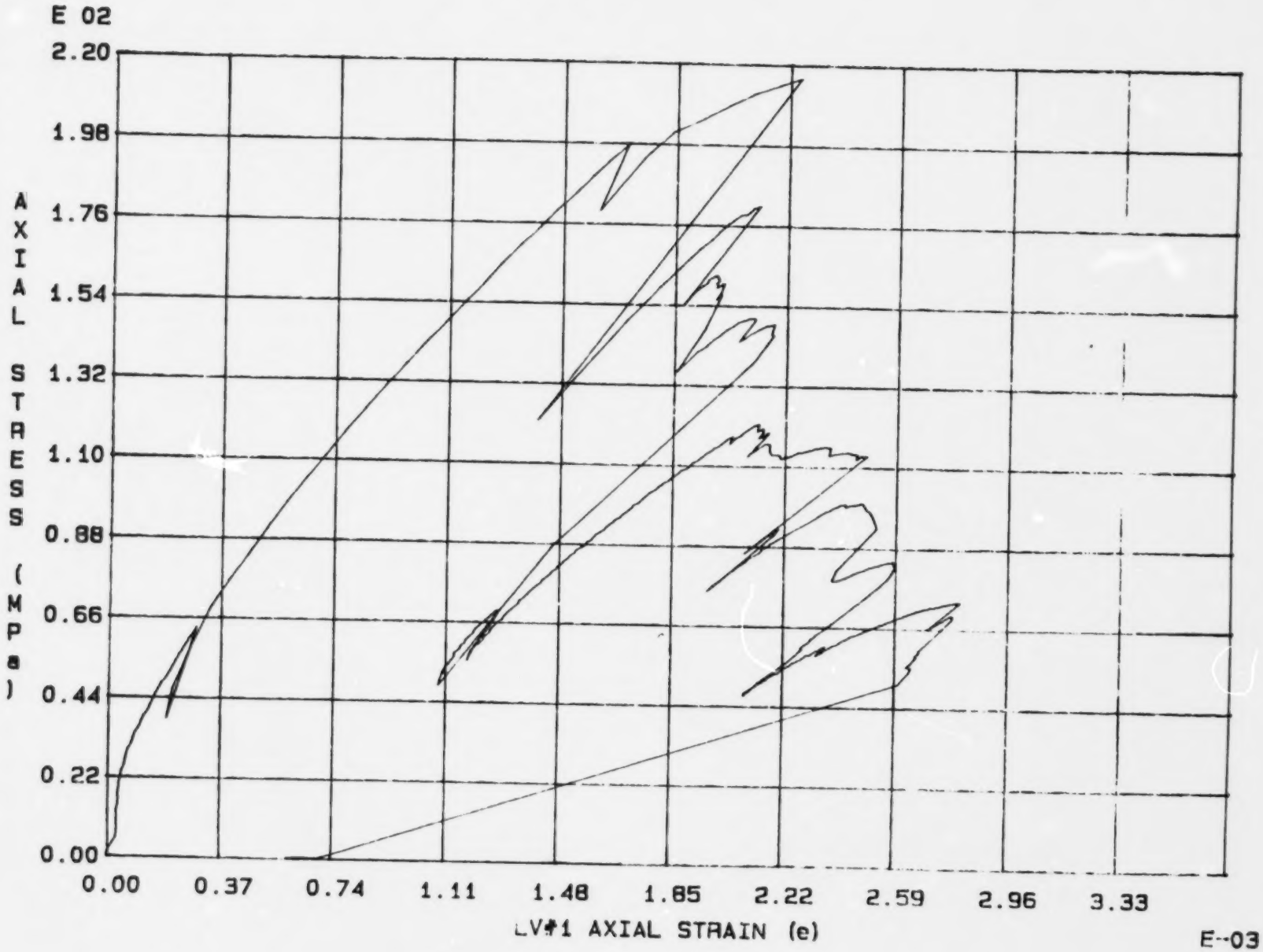

E 02
2.20
1.98
1.76
1.54
1.32
1.10
0.88
0.66
0.44
0.22
0.00
AXIAL STRESS (MPa)
0.00
0.37
0.74
1.11
1.48
1.85
2.22
2.59
2.96
3.33
LV#1 AXIAL STRAIN (e)
E-03

Fig. A-20 F39U

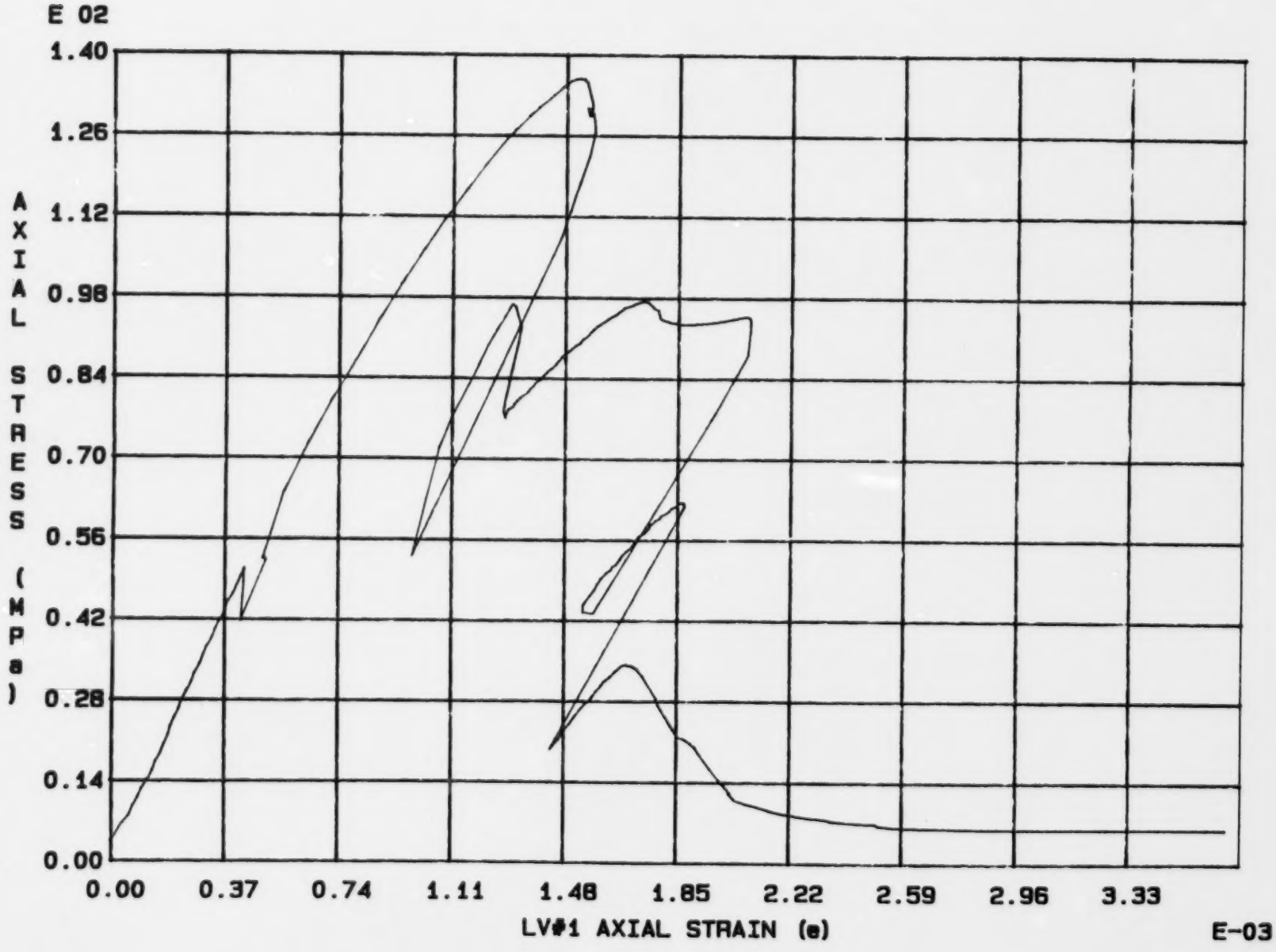

E 02
1.40
1.26
1.12
0.98
0.84
0.70
0.56
0.42
0.28
0.14
0.00
AXIAL STRESS (MPa)
0.00
0.37
0.74
1.11
1.48
1.85
2.22
2.59
2.96
3.33
LV#1 AXIAL STRAIN (e)
E-03

Fig. A-21 E41U

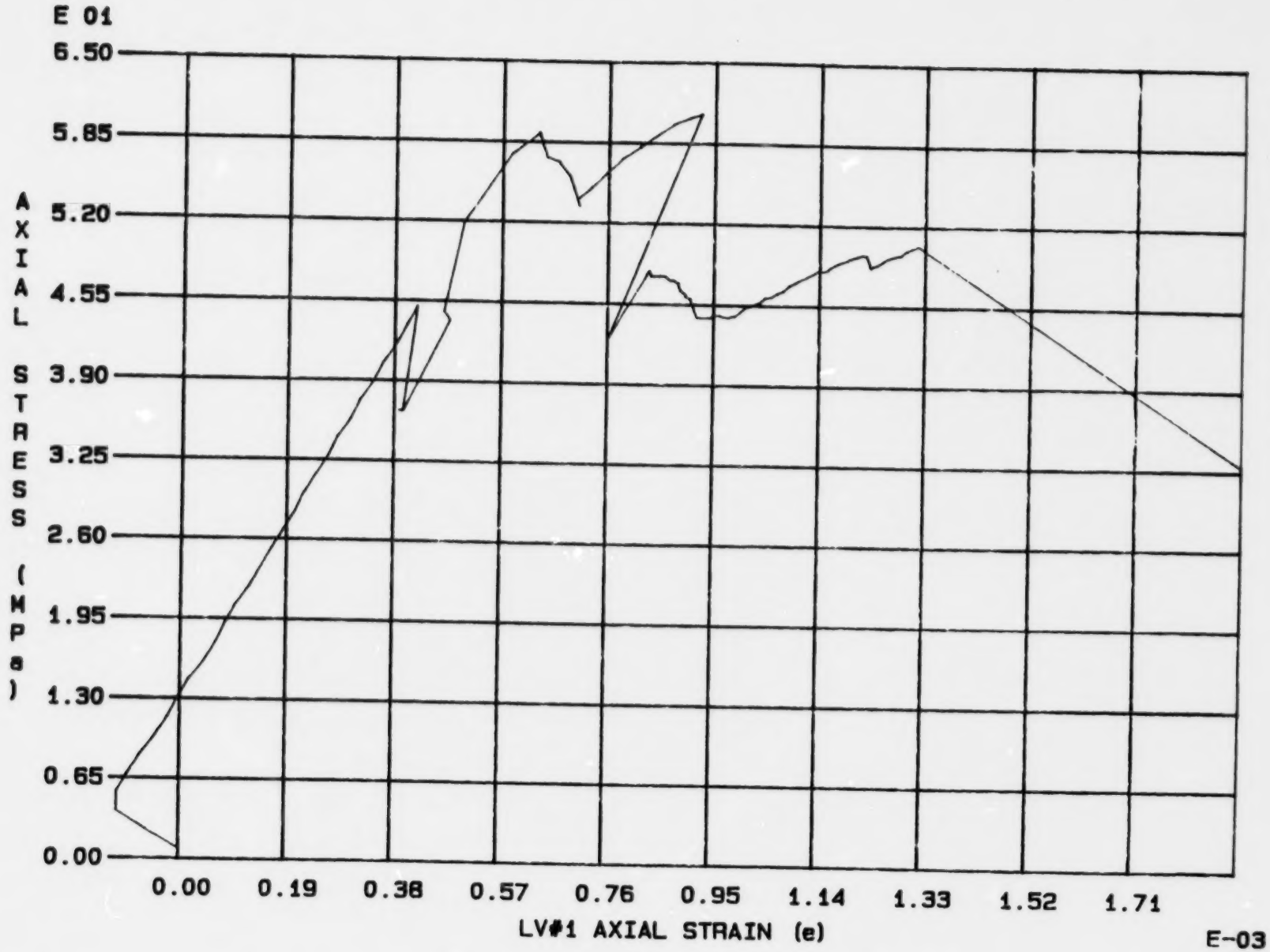

E 01
6.50
5.85
5.20
4.55
3.90
3.25
2.60
1.95
1.30
0.65
0.00
AXIAL STRESS (MPa)
0.00
0.19
0.38
0.57
0.76
0.95
1.14
1.33
1.52
1.71
LV#1 AXIAL STRAIN (e)
E-03

Fig. A-22 E43U

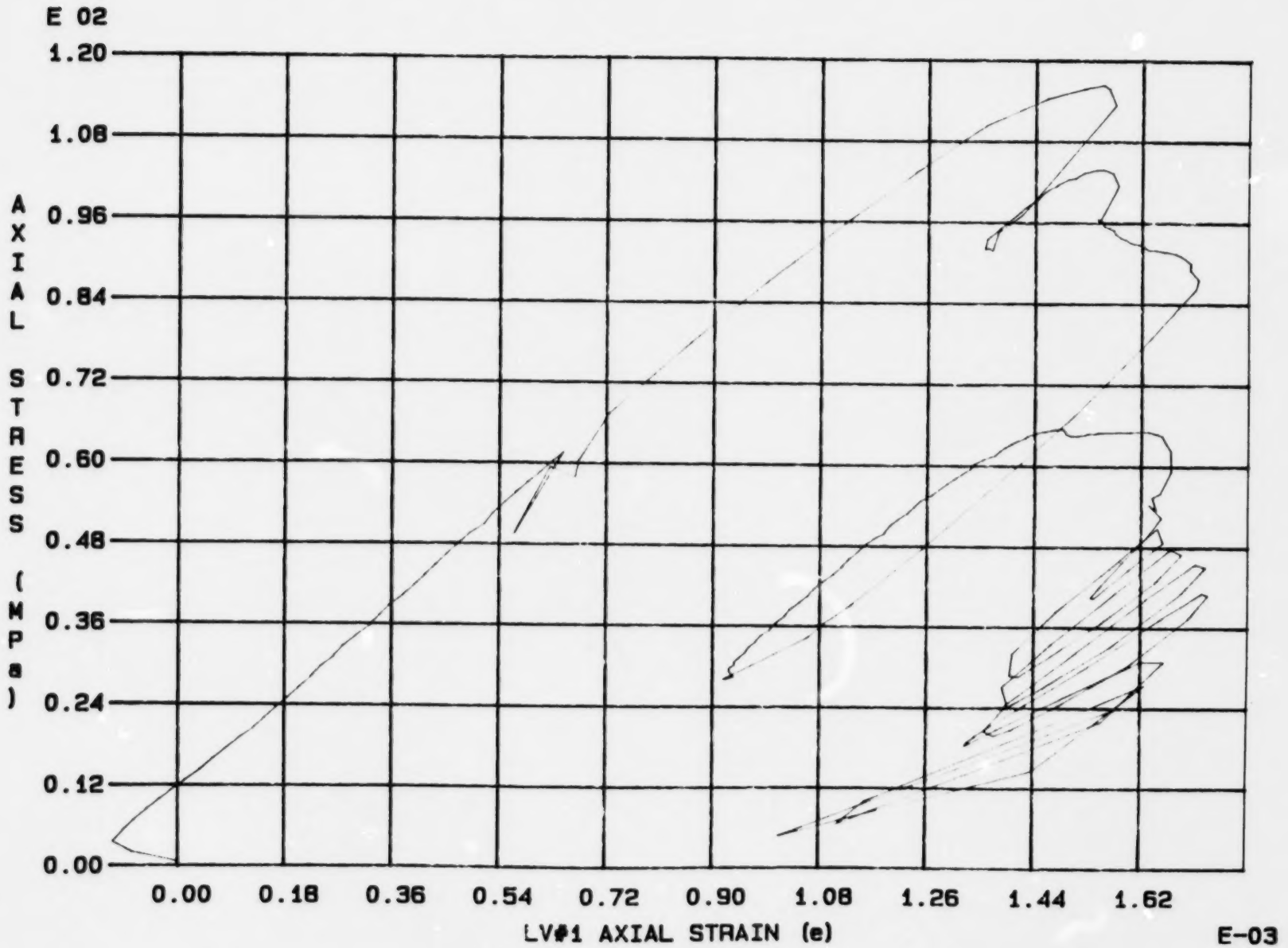

E 02
1.20
1.08
0.96
0.84
0.72
0.60
0.48
0.36
0.24
0.12
0.00
AXIAL STRESS (MPa)
0.00
0.18
0.36
0.54
0.72
0.90
1.08
1.26
1.44
1.62
LV#1 AXIAL STRAIN (e)
E-03

Fig. A-23 E45U

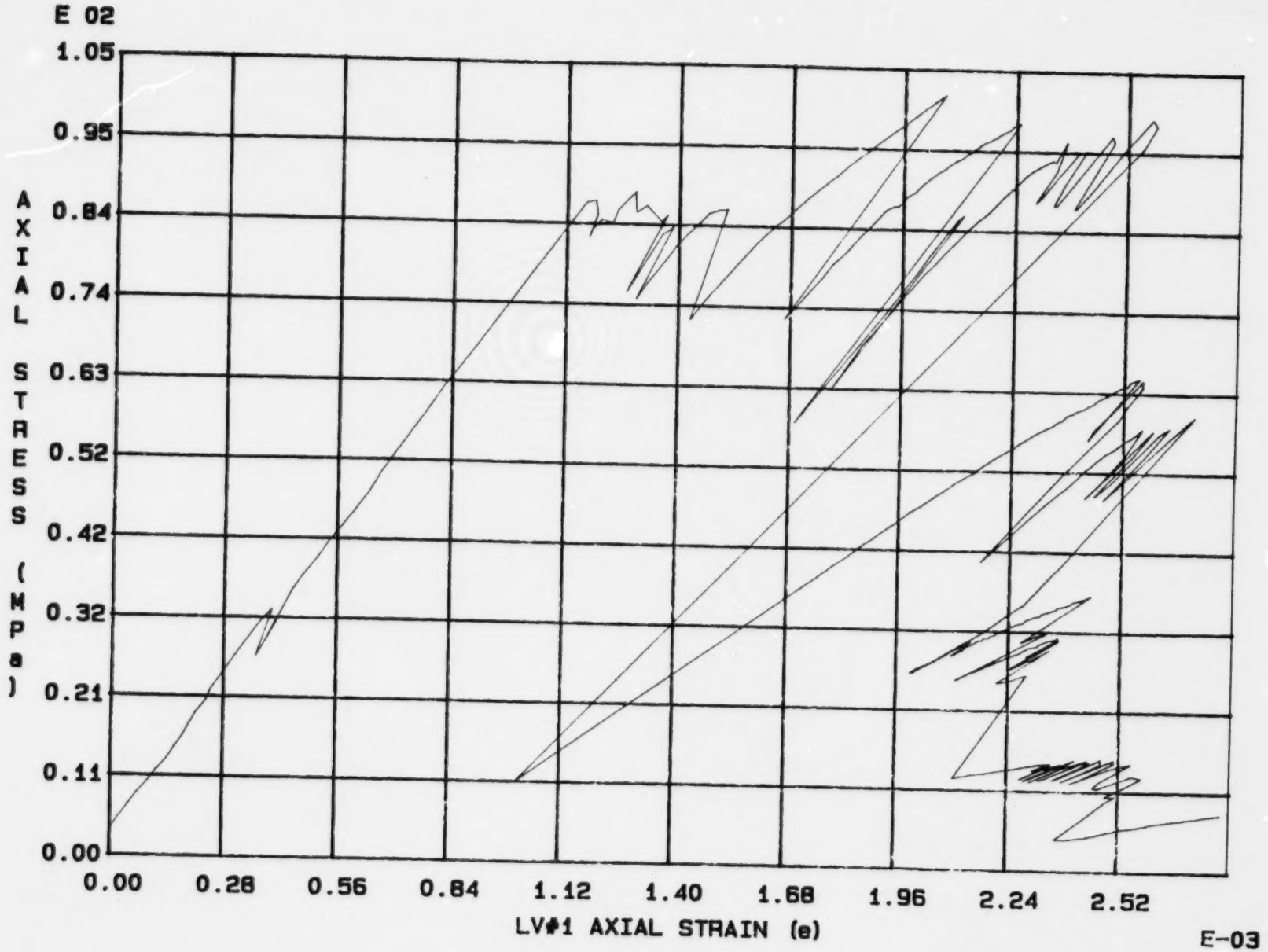

E 02
1.05
0.95
0.84
0.74
0.63
0.52
0.42
0.32
0.21
0.11
0.00
AXIAL STRESS (MPa)
0.00
0.28
0.56
0.84
1.12
1.40
1.68
1.96
2.24
2.52
LV#1 AXIAL STRAIN (e)
E-03

Fig. A-24 E47U

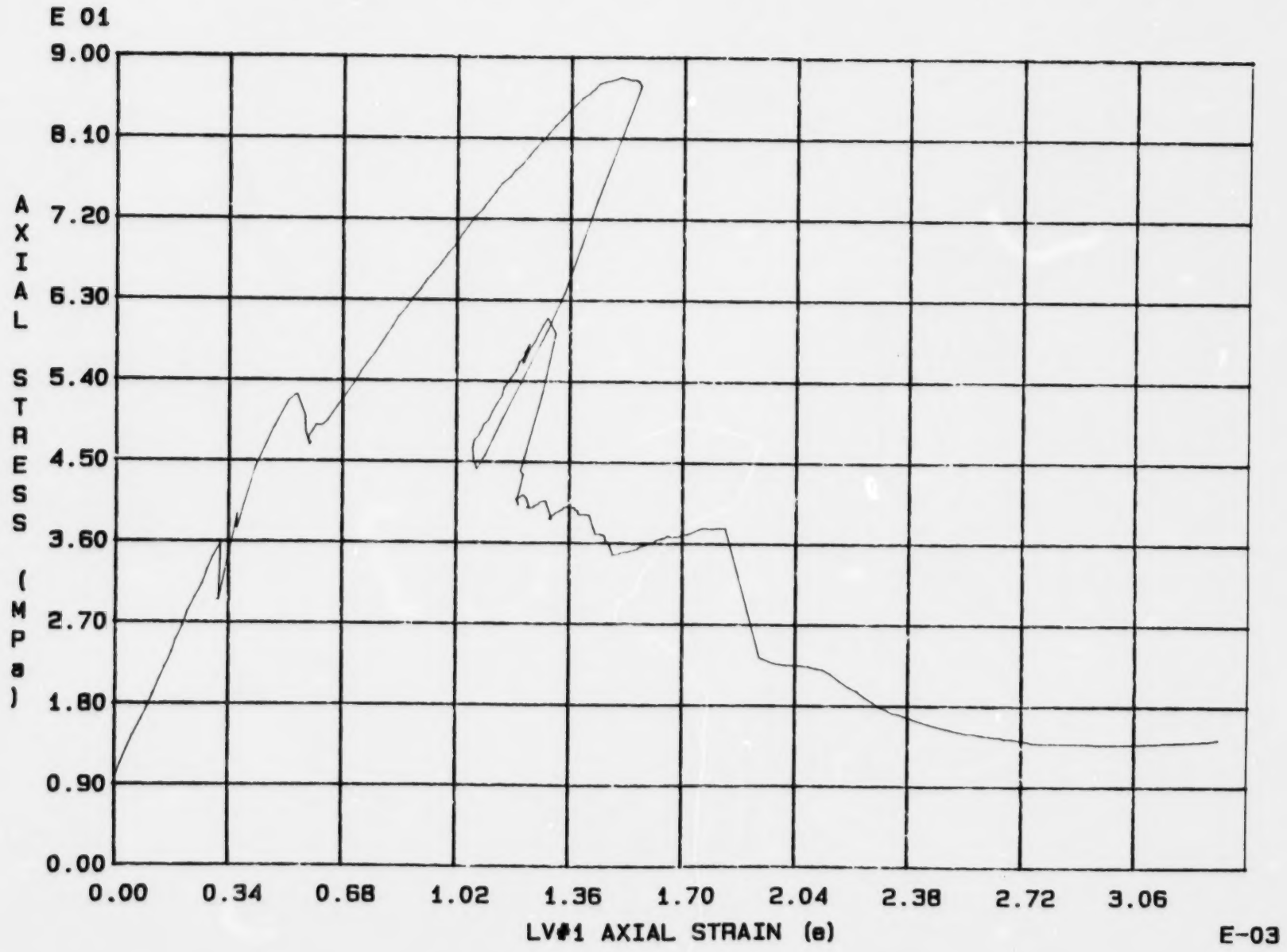

E 01
9.00
8.10
7.20
6.30
5.40
4.50
3.60
2.70
1.80
0.90
0.00
AXIAL STRESS (MPa)
0.00
0.34
0.68
1.02
1.36
1.70
2.04
2.38
2.72
3.06
LV#1 AXIAL STRAIN (e)
E-03

Fig. A-25 E49U

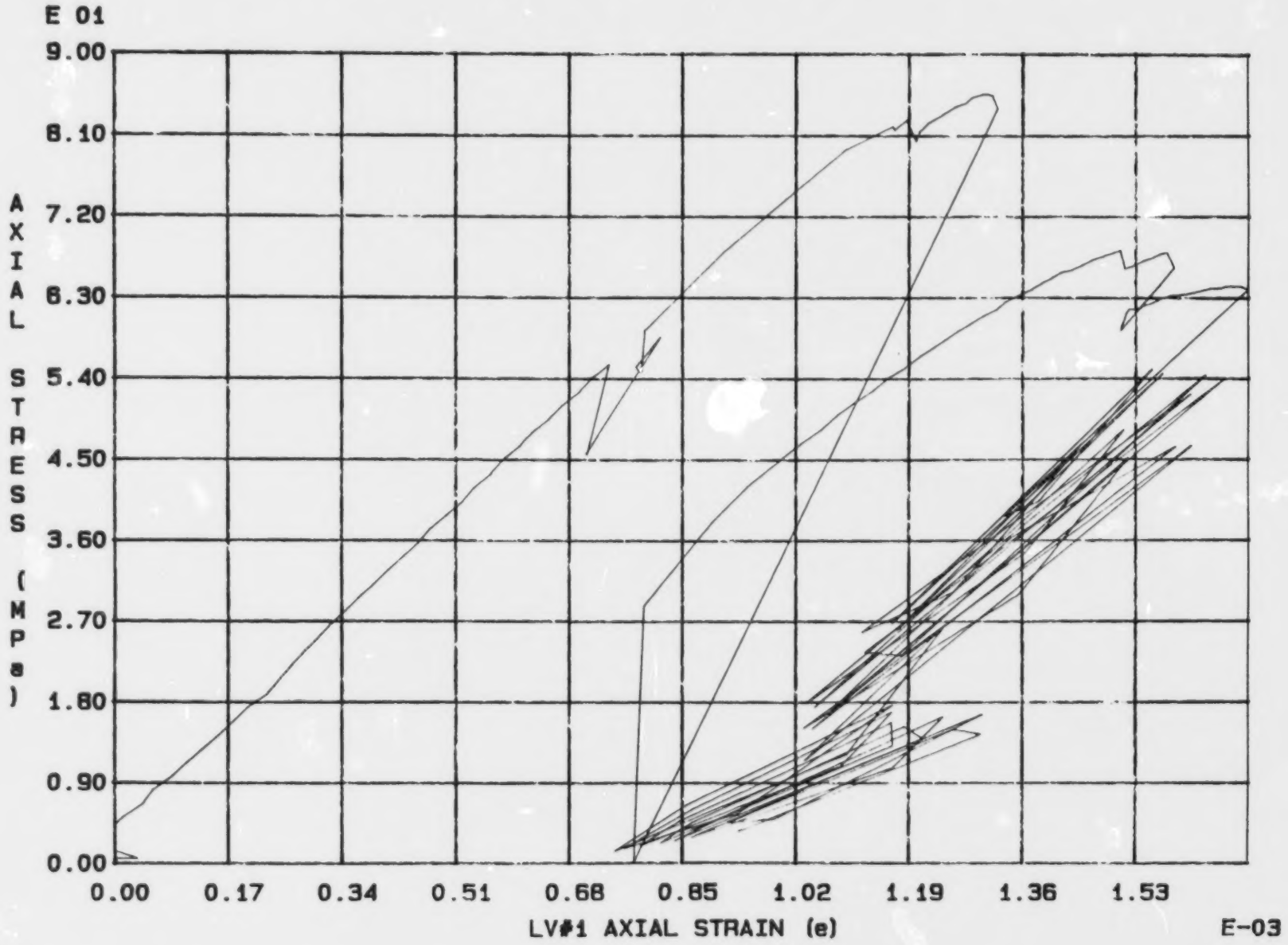
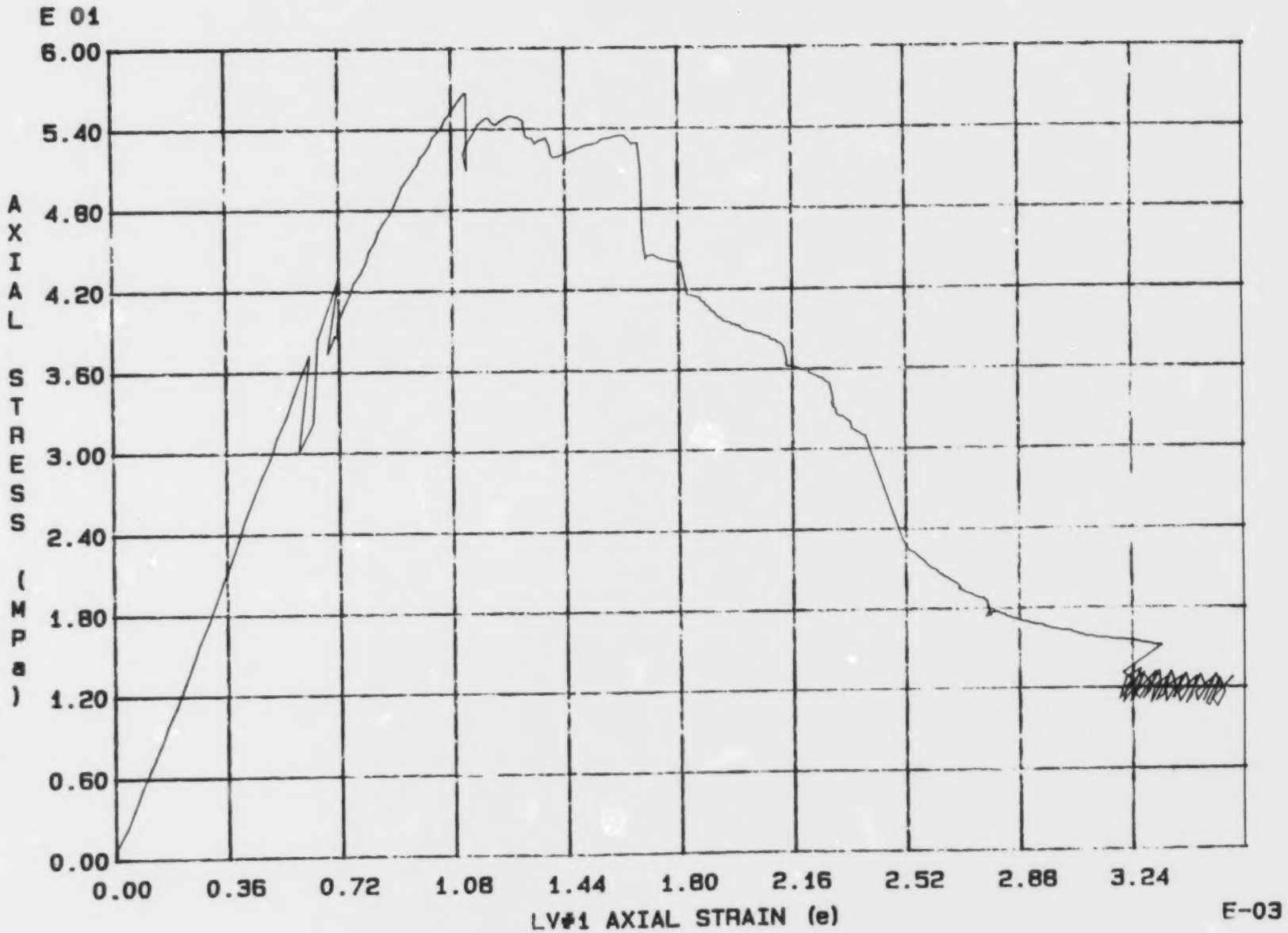

E 01
9.00
8.10
7.20
6.30
5.40
4.50
3.60
2.70
1.80
0.90
0.00
AXIAL STRESS (MPa)
0.00
0.17
0.34
0.51
0.68
0.85
1.02
1.19
1.36
1.53
LV#1 AXIAL STRAIN (e)
E-03

Fig. A-26 E51U


E 01
6.00
5.40
4.80
4.20
3.60
3.00
2.40
1.80
1.20
0.60
0.00
AXIAL STRESS (MPa)
0.00
0.36
0.72
1.08
1.44
1.80
2.16
2.52
2.88
3.24
LV#1 AXIAL STRAIN (e)
E-03

E53U

Fig. A-27

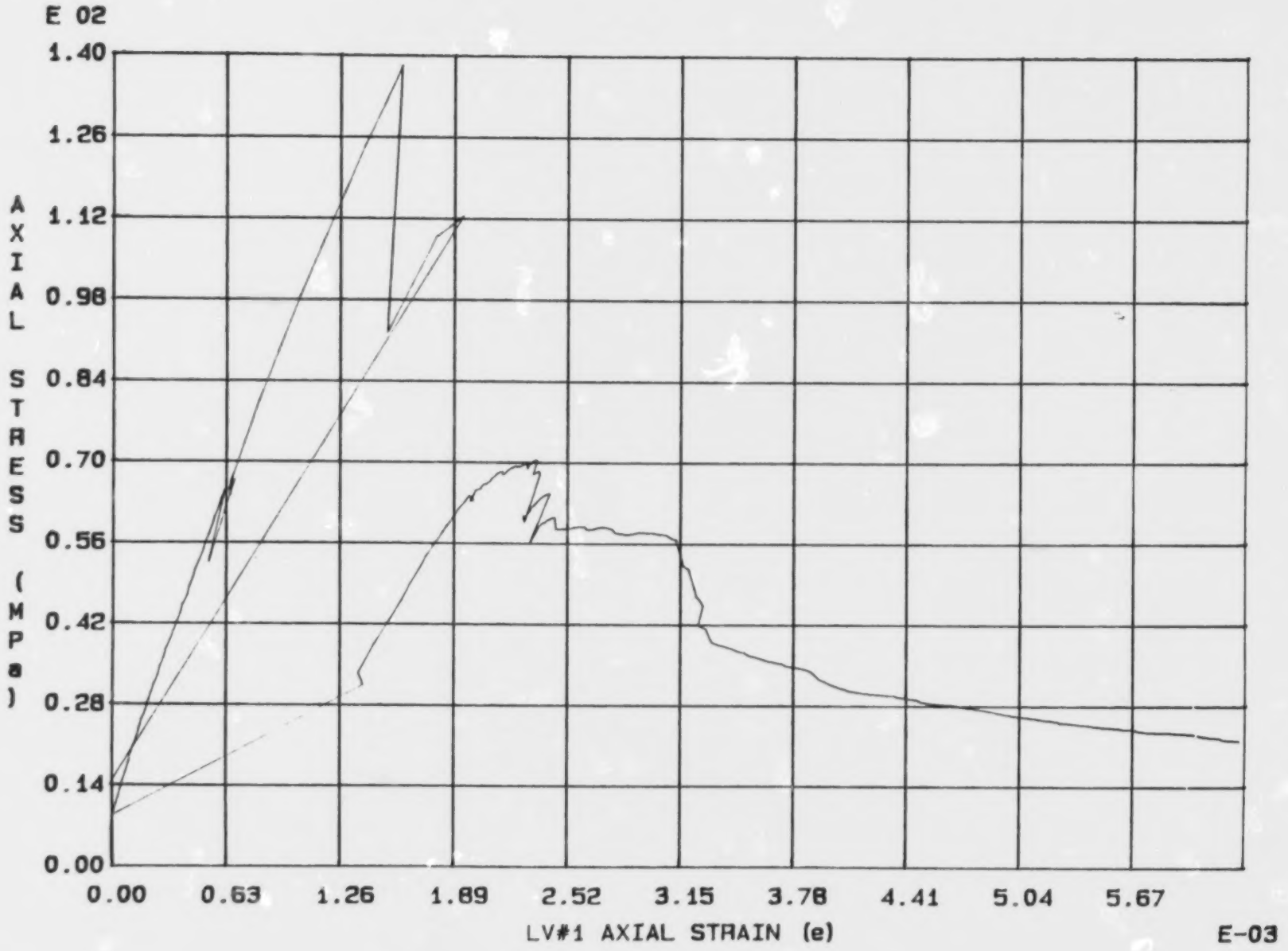

E 02
1.40
1.26
1.12
0.98
0.84
0.70
0.56
0.42
0.28
0.14
0.00
AXIAL STRESS (MPa)
0.00
0.63
1.26
1.89
2.52
3.15
3.78
4.41
5.04
5.67
LV#1 AXIAL STRAIN (e)
E-03

Fig. A-28 E55U

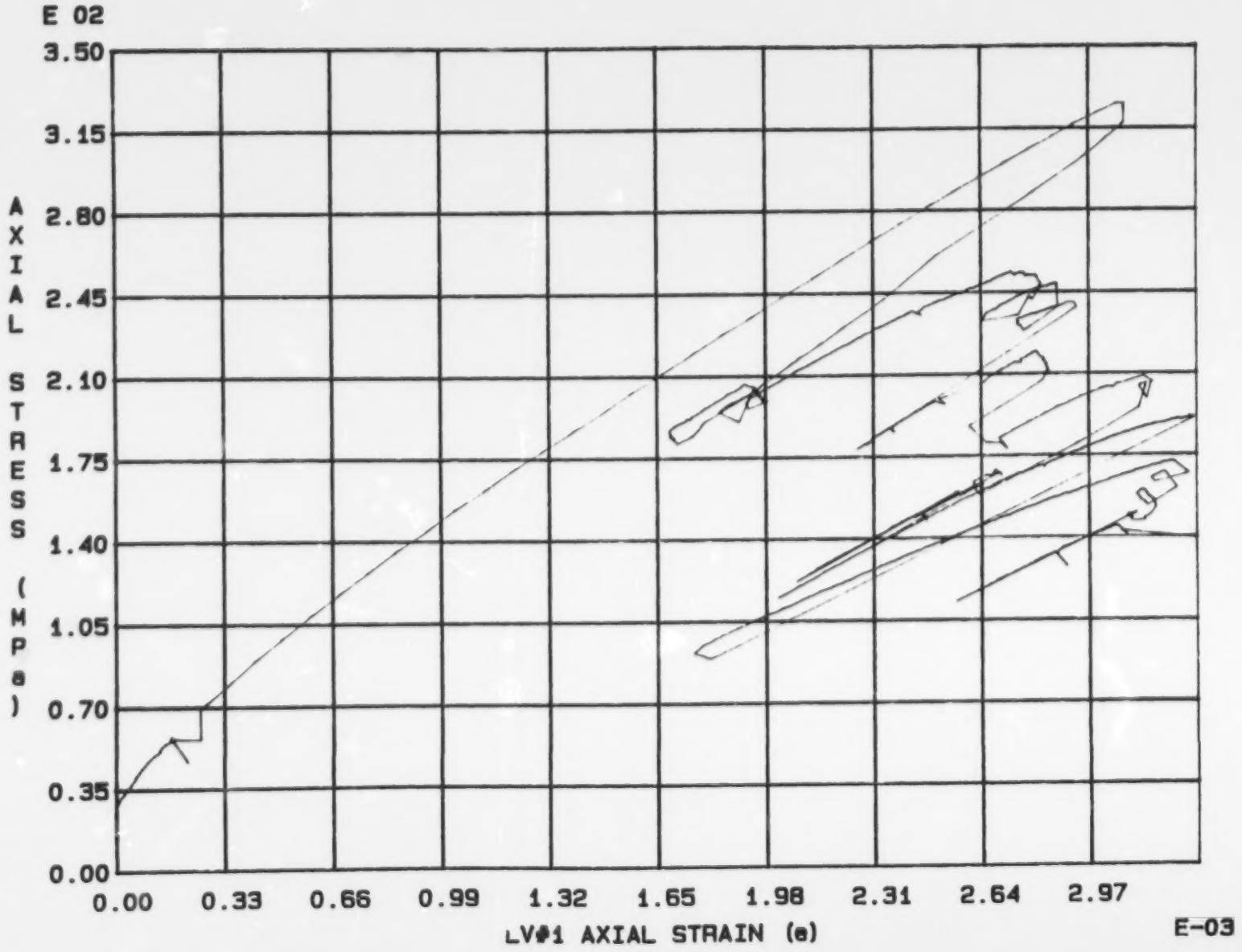

E 02
3.50
3.15
2.80
2.45
2.10
1.75
1.40
1.05
0.70
0.35
0.00
AXIAL STRESS (MPa)
0.00
0.33
0.66
0.99
1.32
1.65
1.98
2.31
2.64
2.97
LV#1 AXIAL STRAIN (e)
E-03

Fig. A-29 E57U

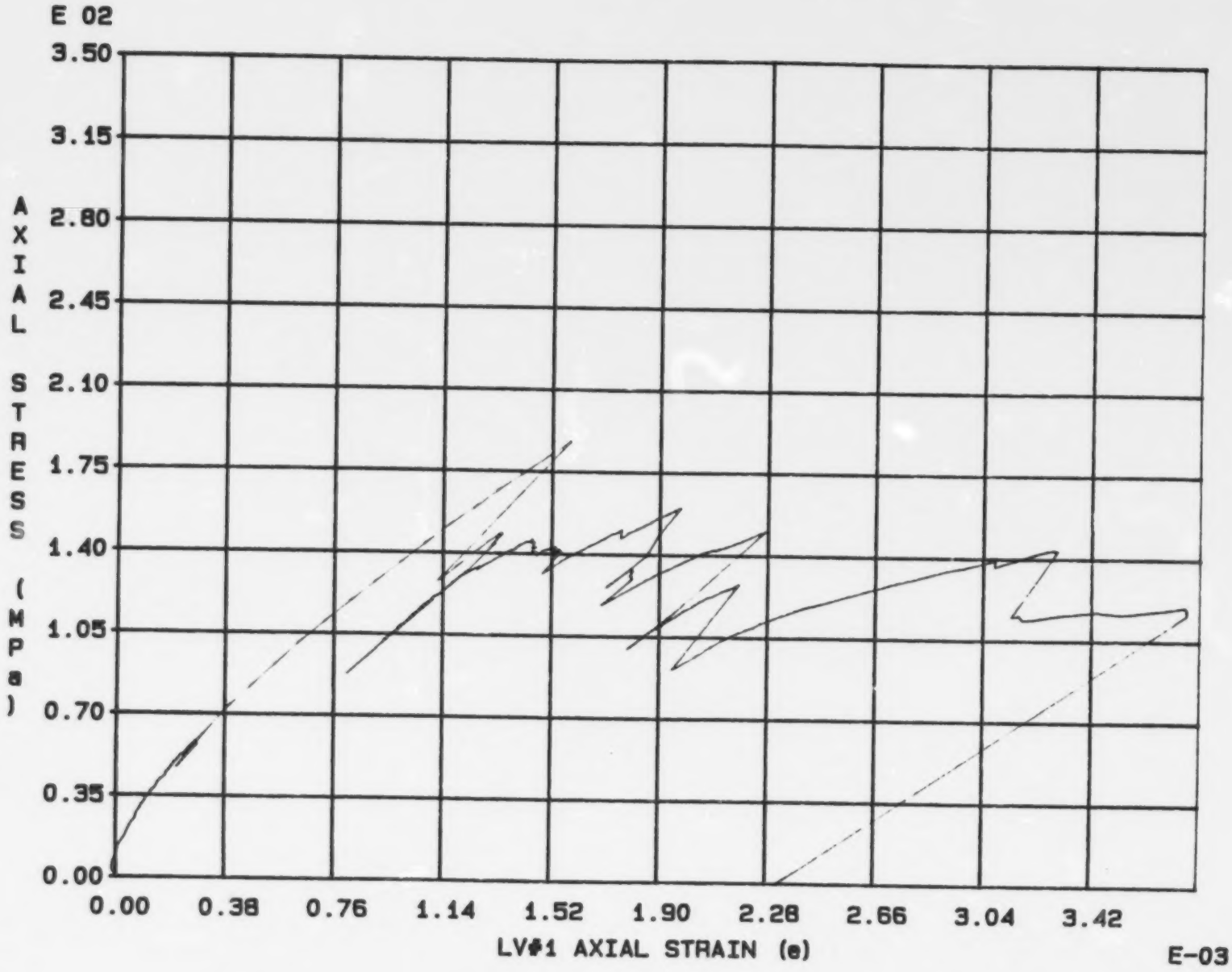

E 02
3.50
3.15
2.80
2.45
2.10
1.75
1.40
1.05
0.70
0.35
0.00
AXIAL STRESS (MPa)
0.00
0.38
0.76
1.14
1.52
1.90
2.28
2.66
3.04
3.42
LV#1 AXIAL STRAIN (e)
E-03

Fig. A-30 E58U

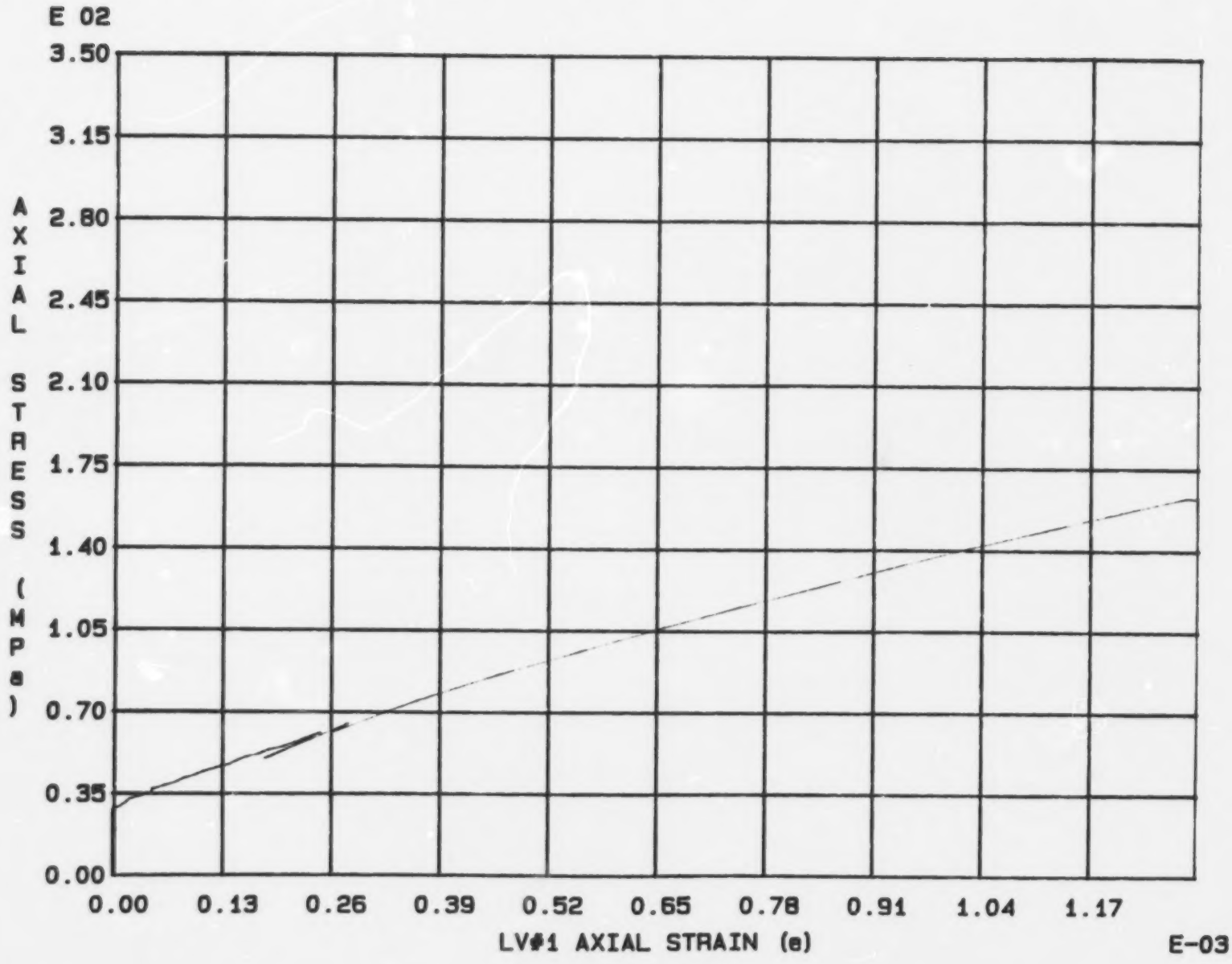

E 02
3.50
3.15
2.80
2.45
2.10
1.75
1.40
1.05
0.70
0.35
0.00
AXIAL STRESS (MPa)
0.00
0.13
0.26
0.39
0.52
0.65
0.78
0.91
1.04
1.17
LV#1 AXIAL STRAIN (e)
E-03

Fig. A-31 E59U

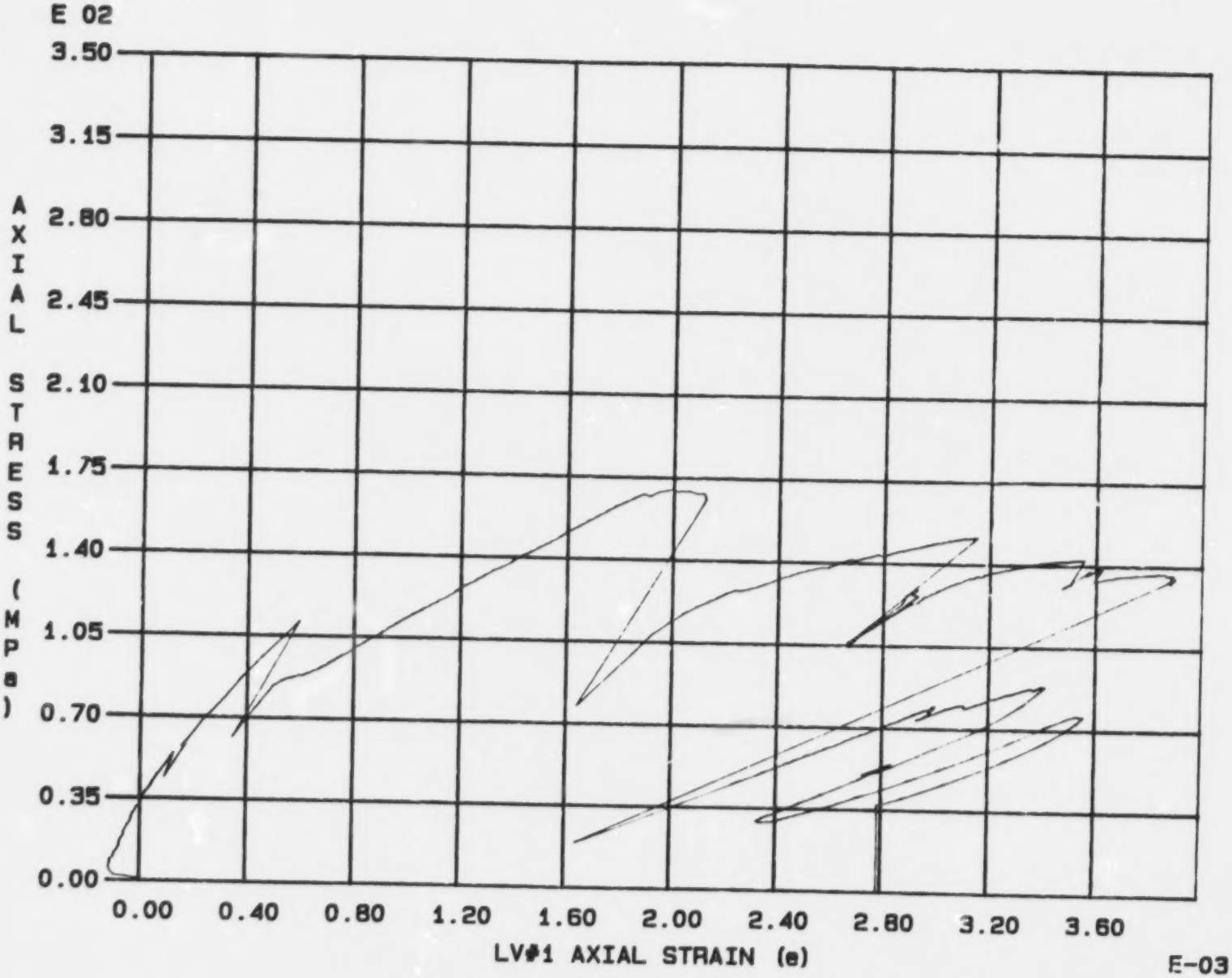

E 02
3.50
3.15
2.80
2.45
2.10
1.75
1.40
1.05
0.70
0.35
0.00
AXIAL STRESS (MPa)
0.00
0.40
0.80
1.20
1.60
2.00
2.40
2.80
3.20
3.60
LV#1 AXIAL STRAIN (e)
E-03

Fig. A-32 E60U

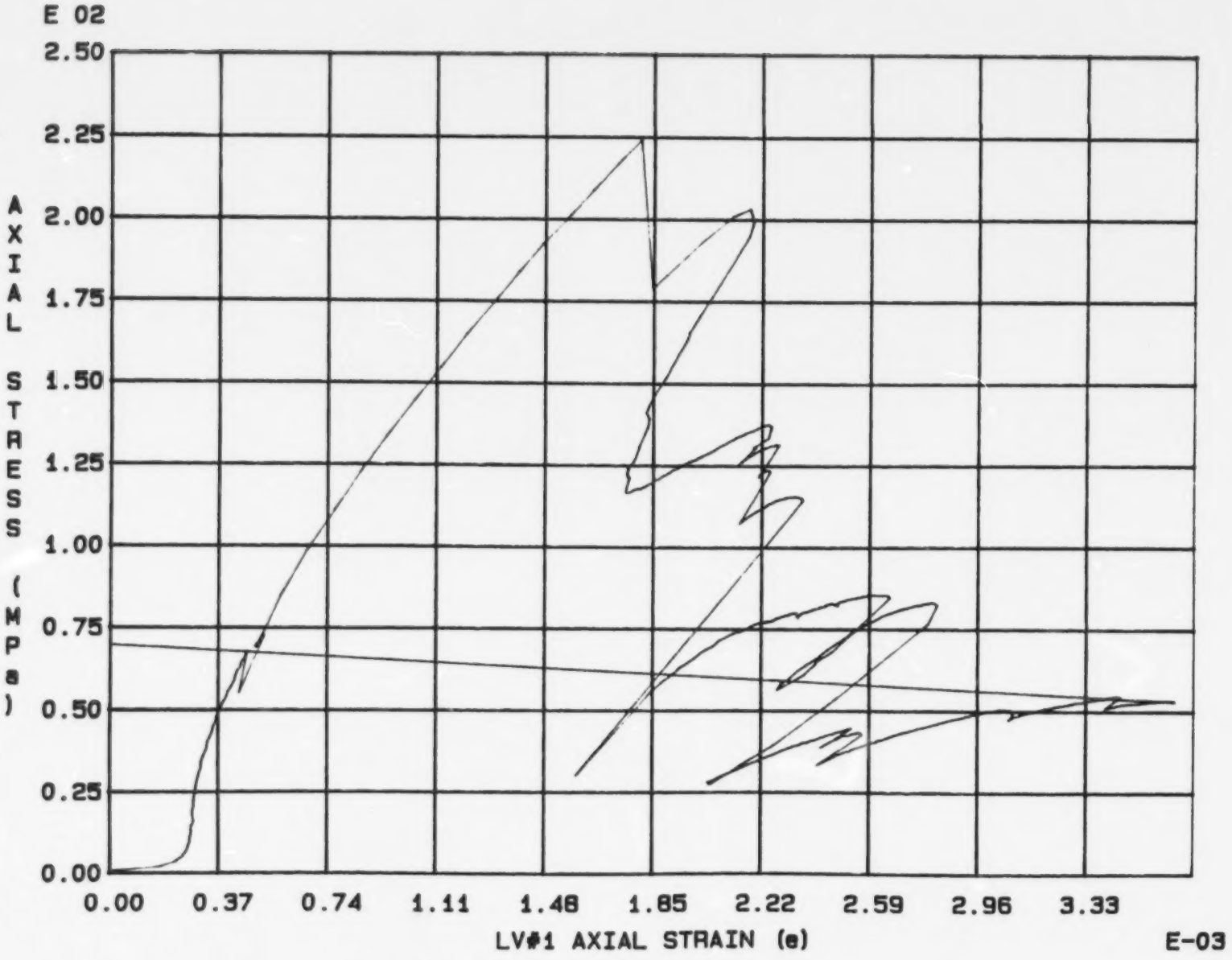

E 02
2.50
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
AXIAL STRESS (MPa)
0.00
0.37
0.74
1.11
1.48
1.85
2.22
2.59
2.96
3.33
LV#1 AXIAL STRAIN (e)
E-03

Fig. A-33 E72U

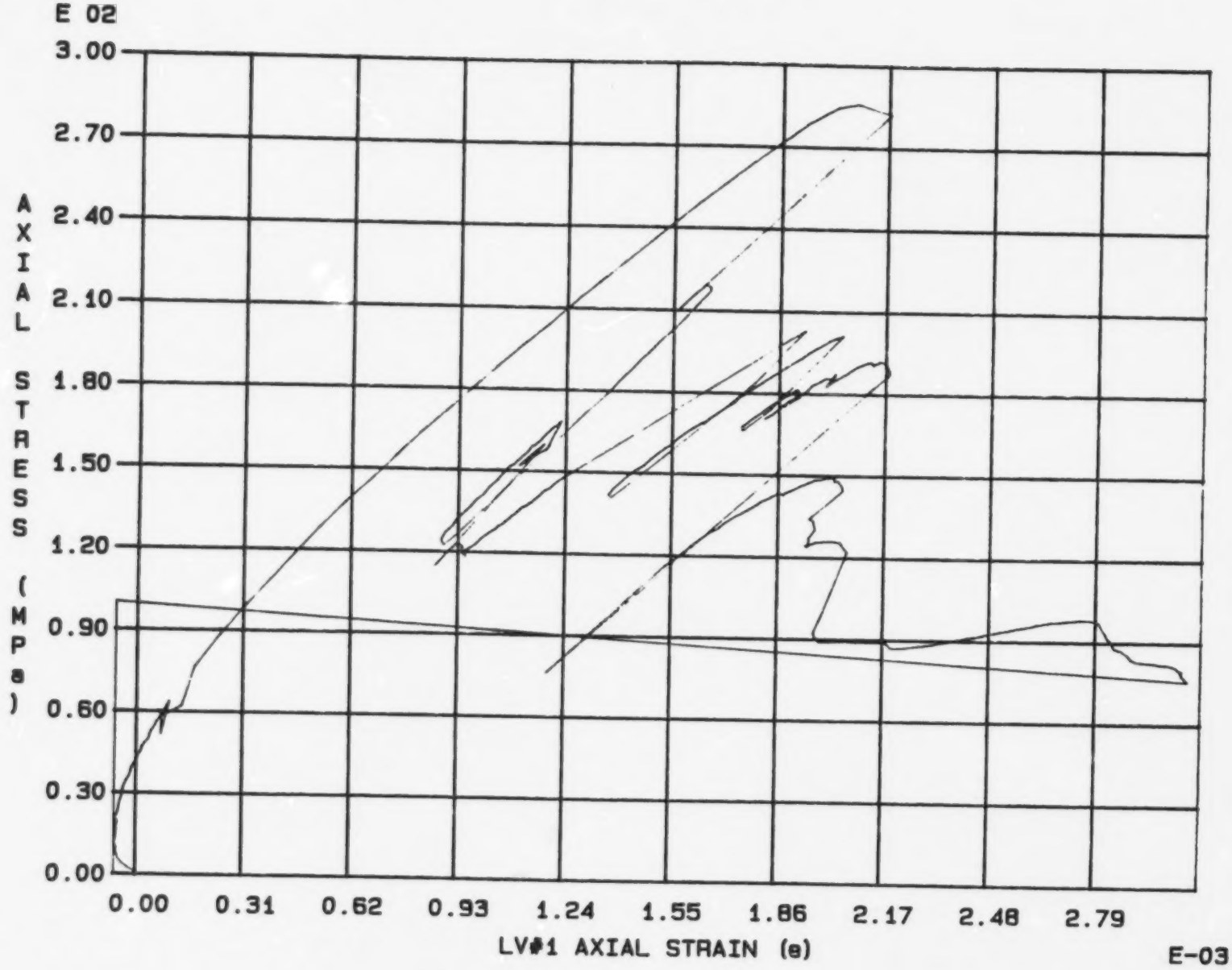

E 02
3.00
2.70
2.40
2.10
1.80
1.50
1.20
0.90
0.60
0.30
0.00
AXIAL STRESS (MPa)
0.00
0.31
0.62
0.93
1.24
1.55
1.86
2.17
2.48
2.79
LV#1 AXIAL STRAIN (e)
E-03

Fig. A-34 E73U

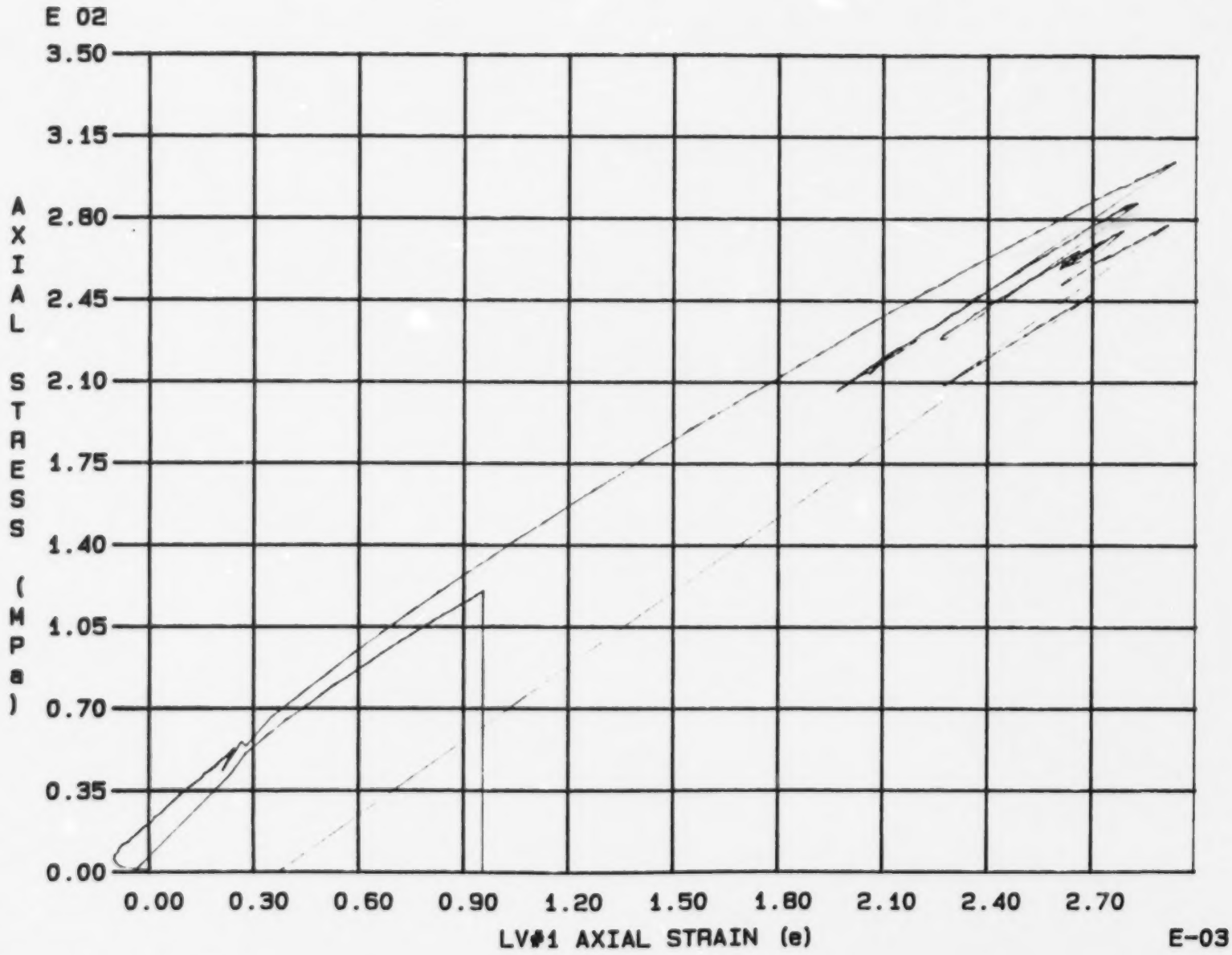

E 02
3.50
3.15
2.80
2.45
2.10
1.75
1.40
1.05
0.70
0.35
0.00
AXIAL STRESS (MPa)
0.00
0.30
0.60
0.90
1.20
1.50
1.80
2.10
2.40
2.70
LV#1 AXIAL STRAIN (e)
E-03

Fig. A-35 E74U

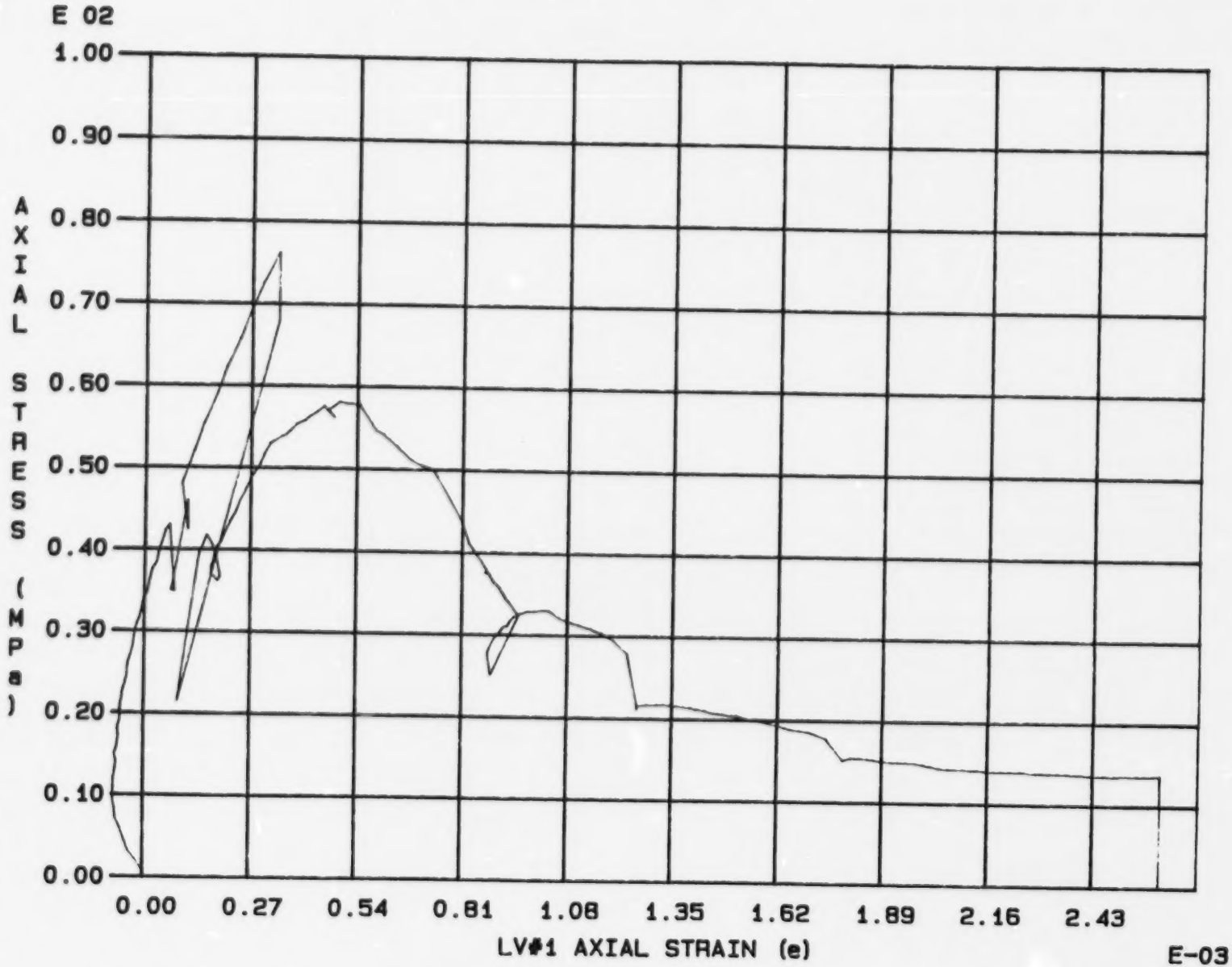

E 02
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
AXIAL STRESS (MPa)
0.00
0.27
0.54
0.81
1.08
1.35
1.62
1.89
2.16
2.43
LV#1 AXIAL STRAIN (e)
E-03

Fig. A-36 E75U

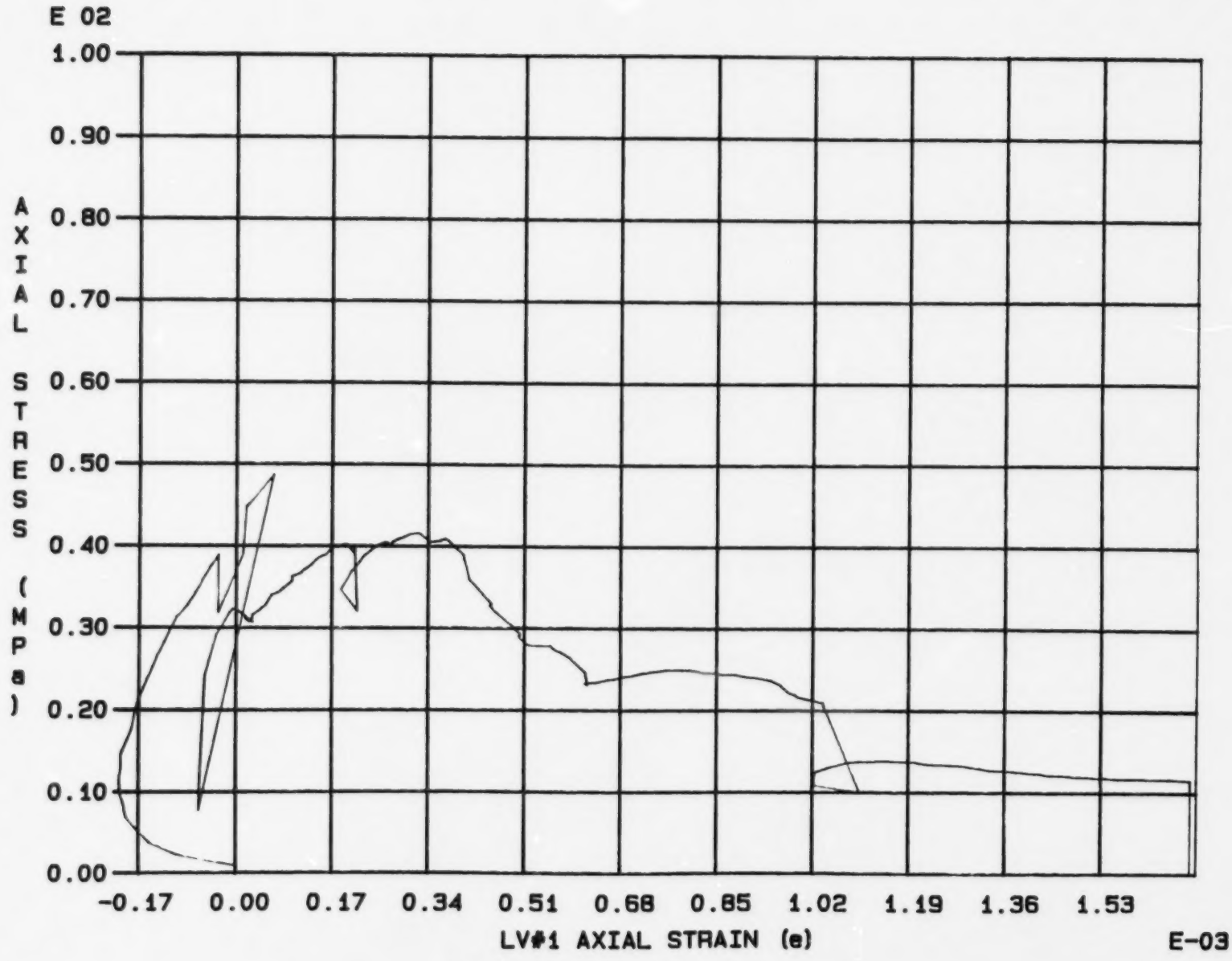

E 02
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
AXIAL STRESS (MPa)
-0.17
0.00
0.17
0.34
0.51
0.68
0.85
1.02
1.19
1.36
1.53
LV#1 AXIAL STRAIN (e)
E-03

Fig. A-37 E76U

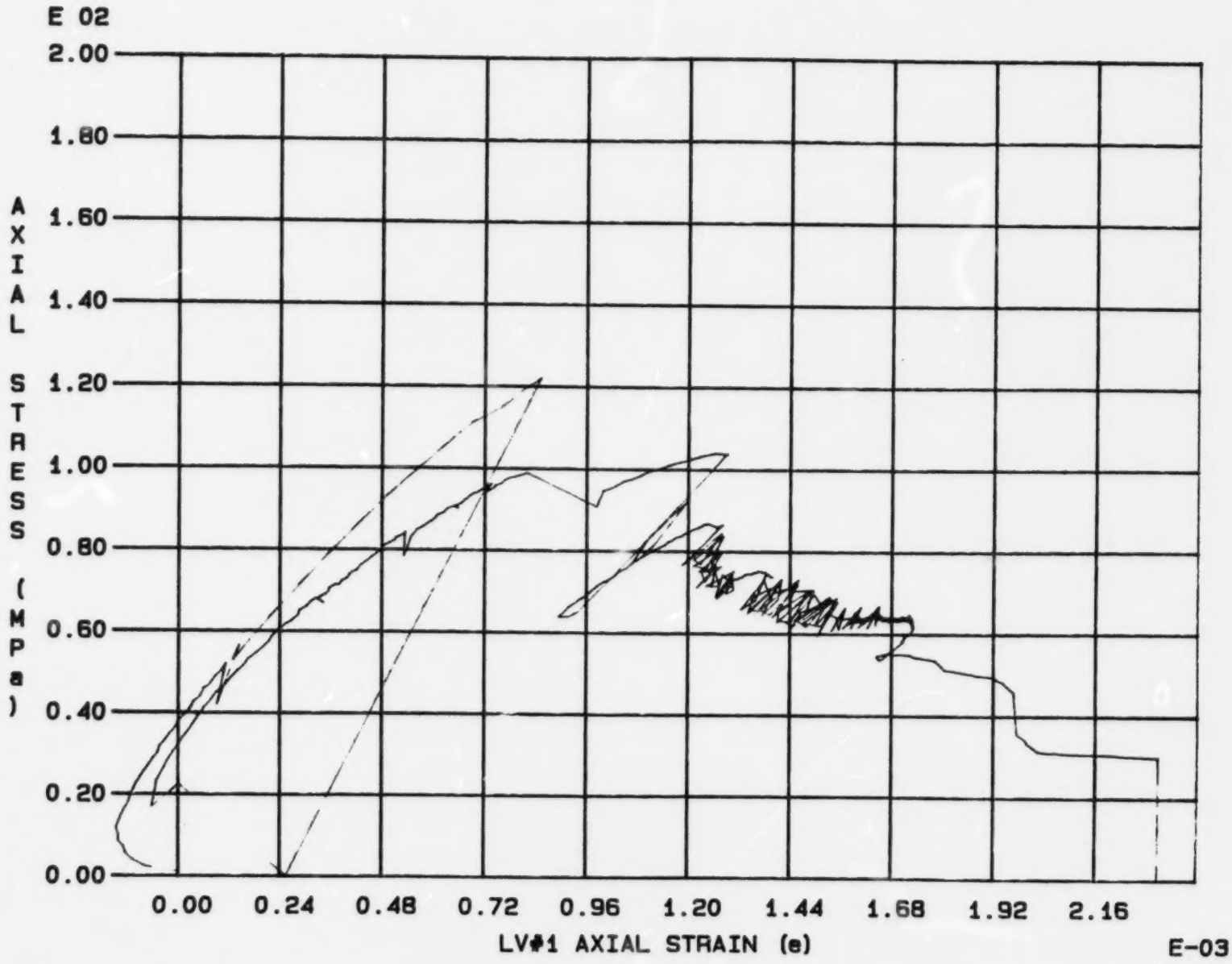

E 02
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
AXIAL STRESS (MPa)
0.00
0.24
0.48
0.72
0.96
1.20
1.44
1.68
1.92
2.16
LV#1 AXIAL STRAIN (e)
E-03

Fig. A-38 E77U

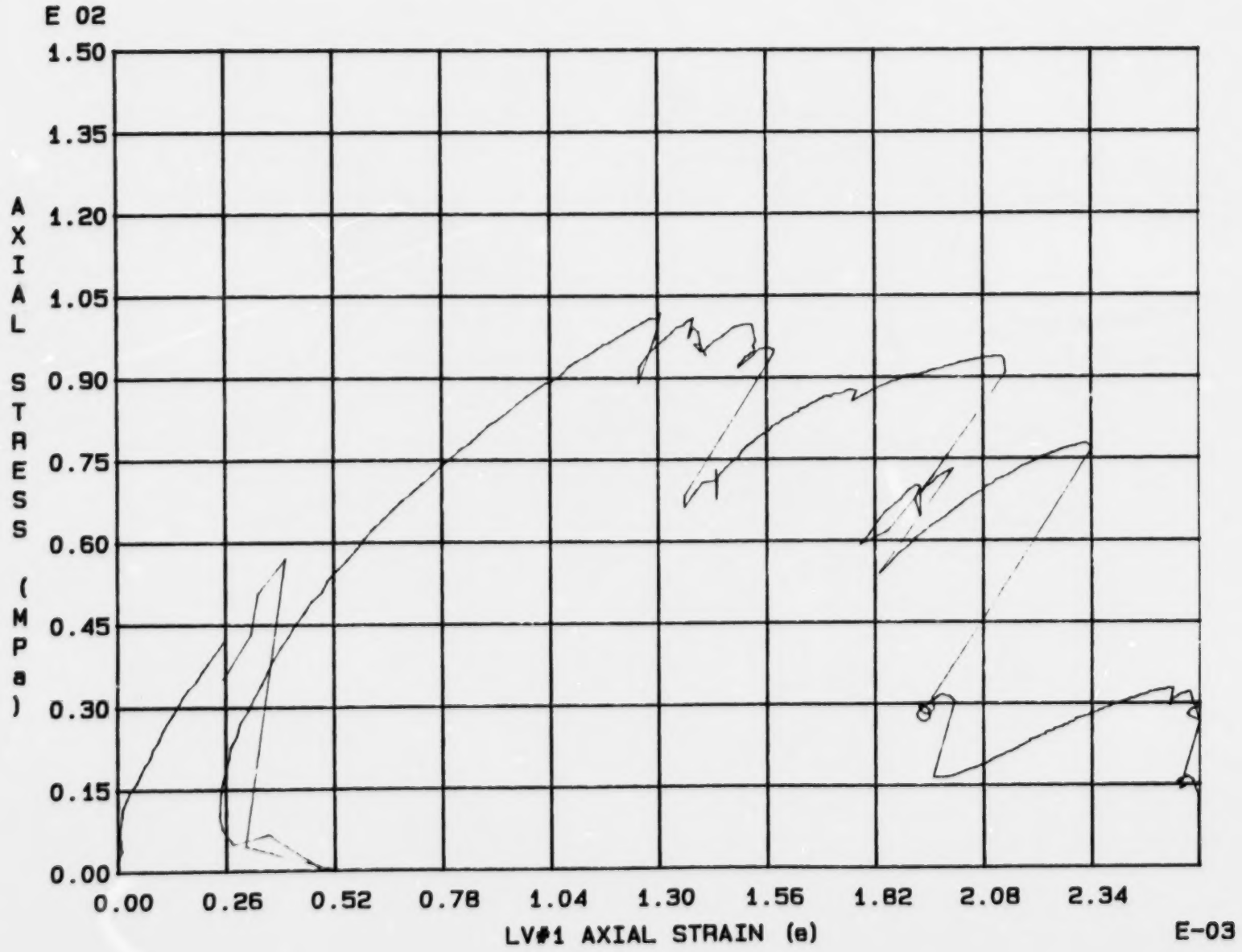

E 02
1.50
1.35
1.20
1.05
0.90
0.75
0.60
0.45
0.30
0.15
0.00
AXIAL STRESS (MPa)
0.00
0.26
0.52
0.78
1.04
1.30
1.56
1.82
2.08
2.34
LV#1 AXIAL STRAIN (e)
E-03

Fig. A-39 E78U

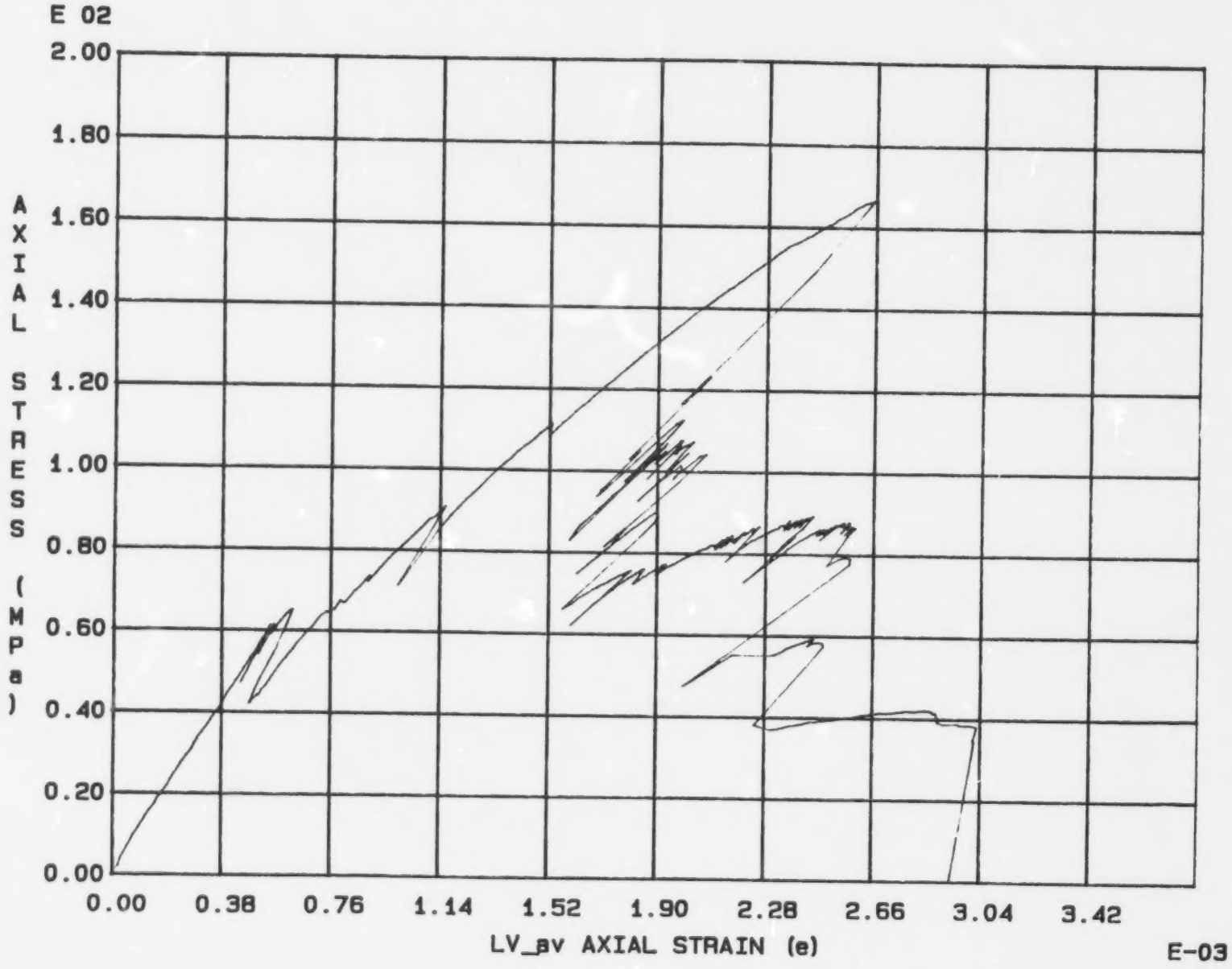

E 02
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
AXIAL STRESS (MPa)
0.00
0.38
0.76
1.14
1.52
1.90
2.28
2.66
3.04
3.42
LV_av AXIAL STRAIN (e)
E-03

Fig. A-40 E79U

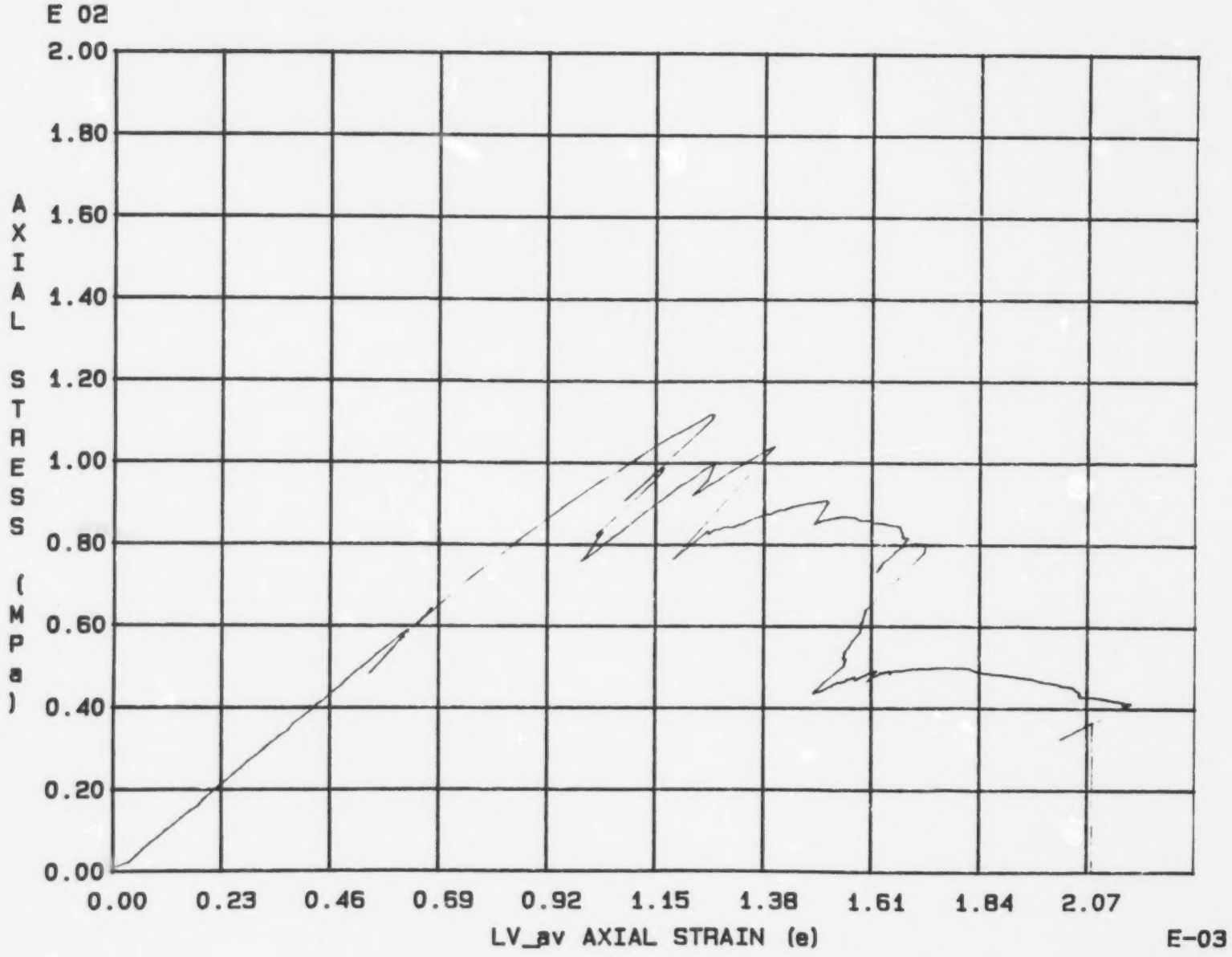

E 02
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
AXIAL STRESS (MPa)
0.00
0.23
0.46
0.69
0.92
1.15
1.38
1.61
1.84
2.07
LV_av AXIAL STRAIN (e)
E-03

Fig. A-41 E80U

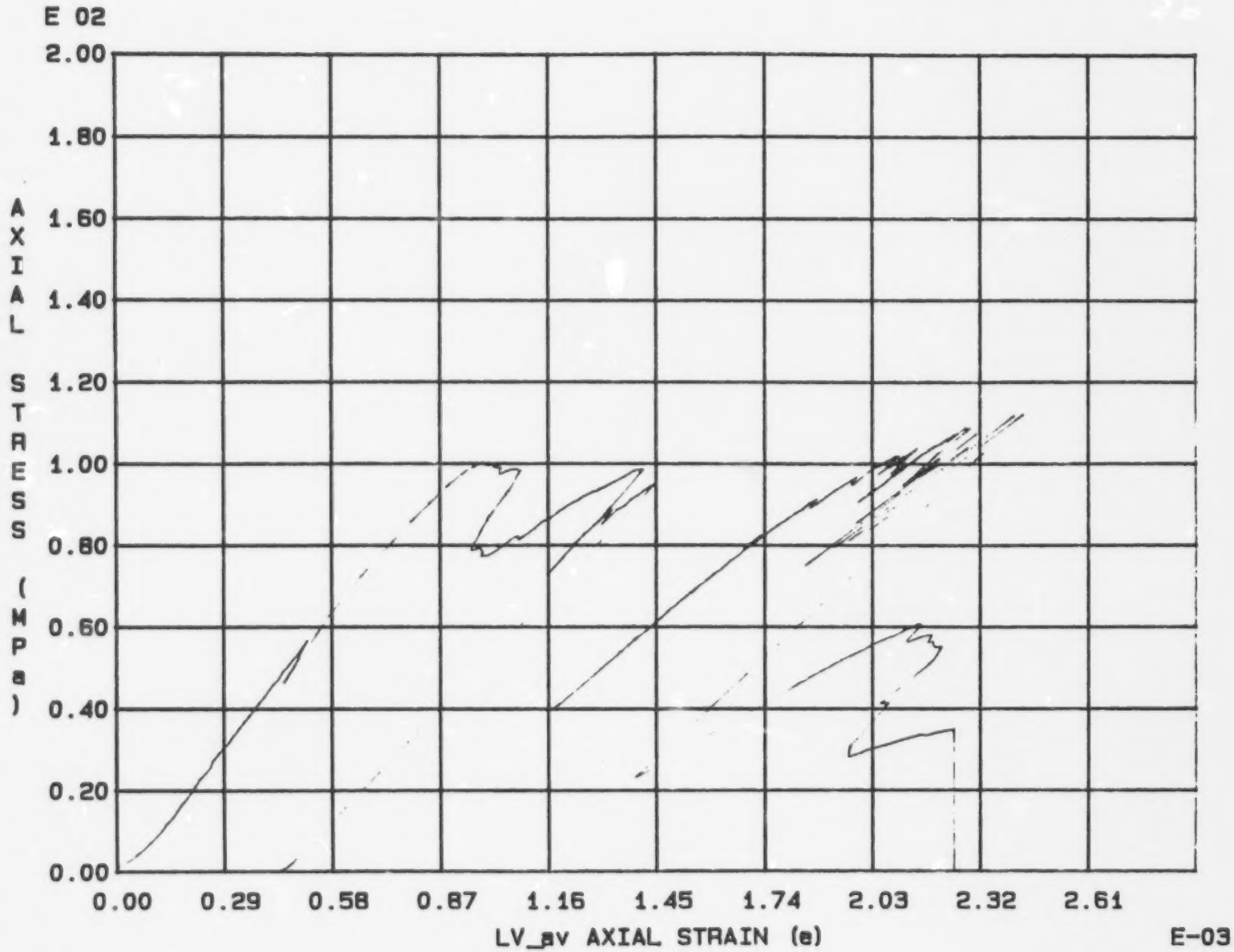

E 02
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
AXIAL STRESS (MPa)
0.00
0.29
0.58
0.87
1.16
1.45
1.74
2.03
2.32
2.61
LV_av AXIAL STRAIN (e)
E-03

Fig. A-42 E81U

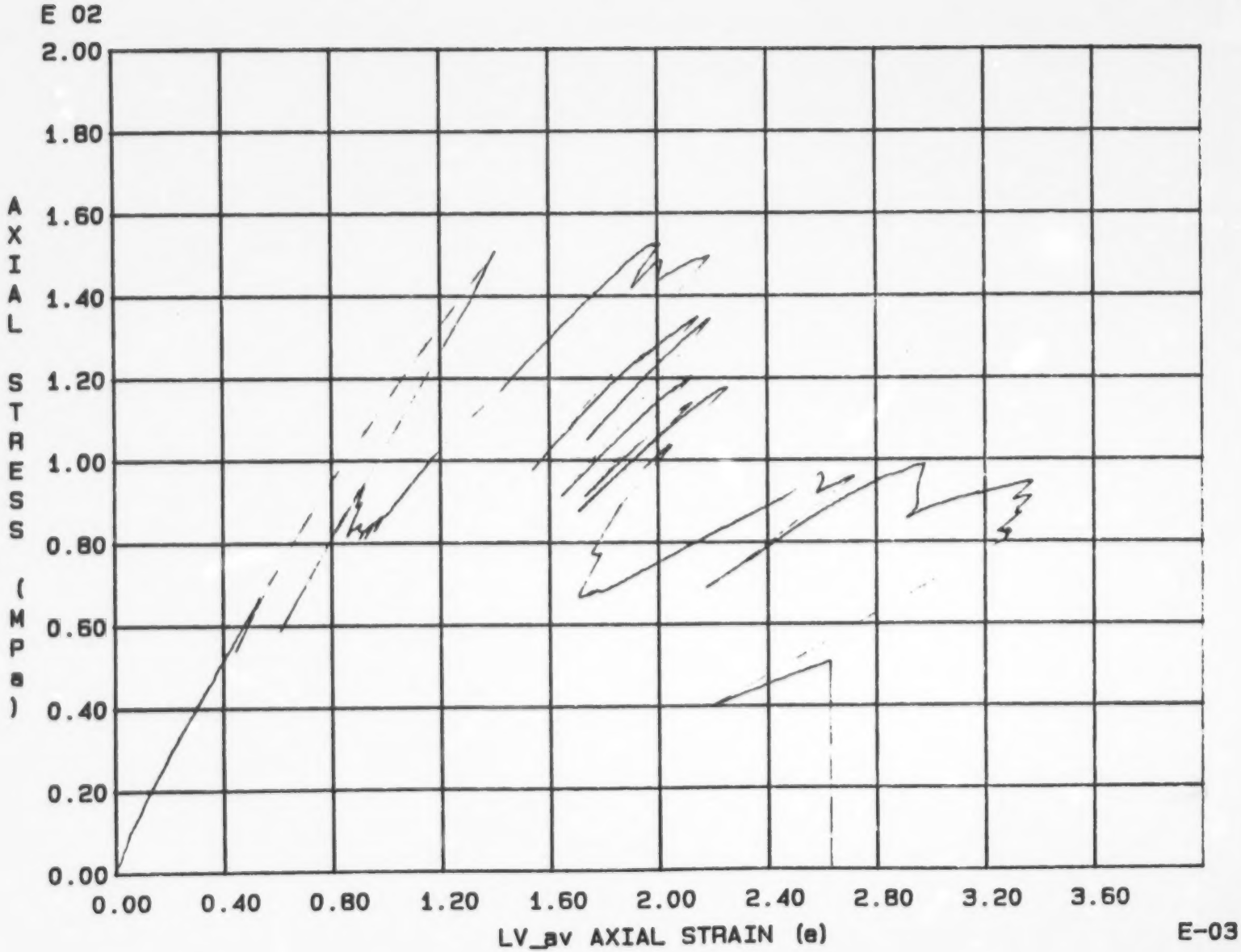

E 02
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
AXIAL STRESS (MPa)
0.00
0.40
0.80
1.20
1.60
2.00
2.40
2.80
3.20
3.60
LV_av AXIAL STRAIN (e)
E-03

Fig. A-43 E82U

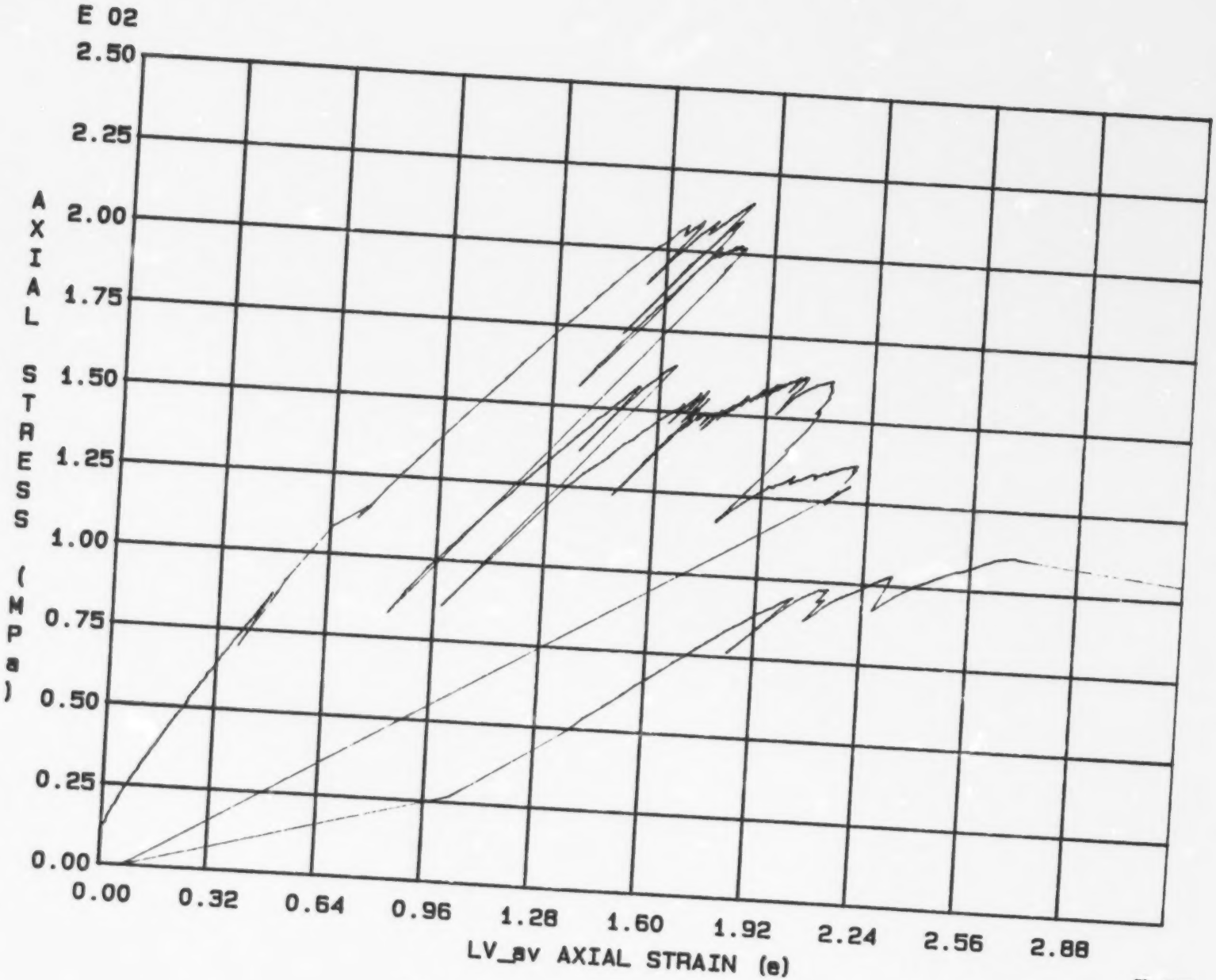

E 02
2.50
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
AXIAL STRESS (MPa)
0.00
0.32
0.64
0.96
1.28
1.60
1.92
2.24
2.56
2.88
LV_av AXIAL STRAIN (e)
E-03

Fig. A-44 E83U

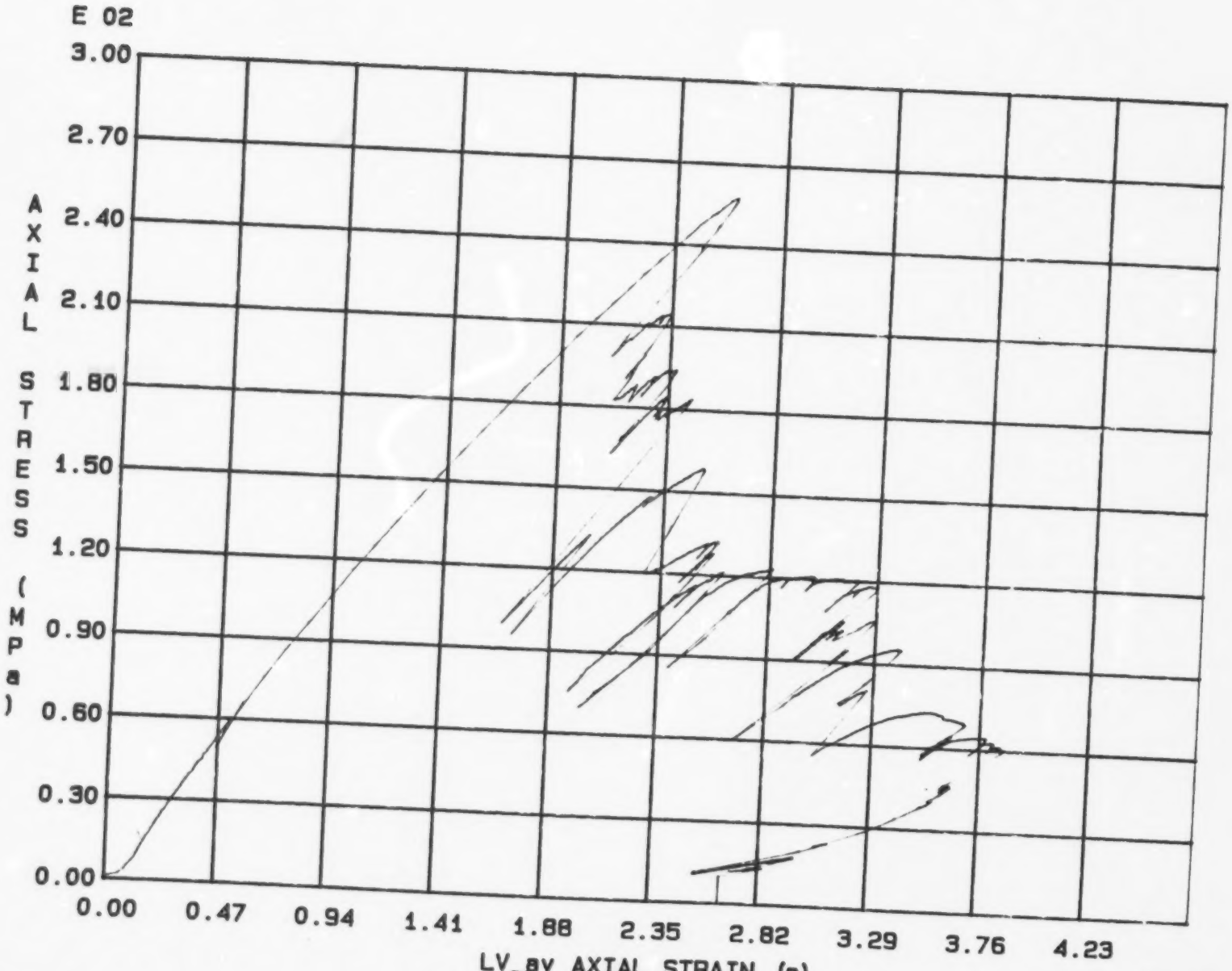

E 02
3.00
2.70
2.40
2.10
1.80
1.50
1.20
0.90
0.60
0.30
0.00
AXIAL STRESS (MPa)
0.00
0.47
0.94
1.41
1.88
2.35
2.82
3.29
3.76
4.23
LV_av AXIAL STRAIN (e)
E-03

Fig. A-45 E84U

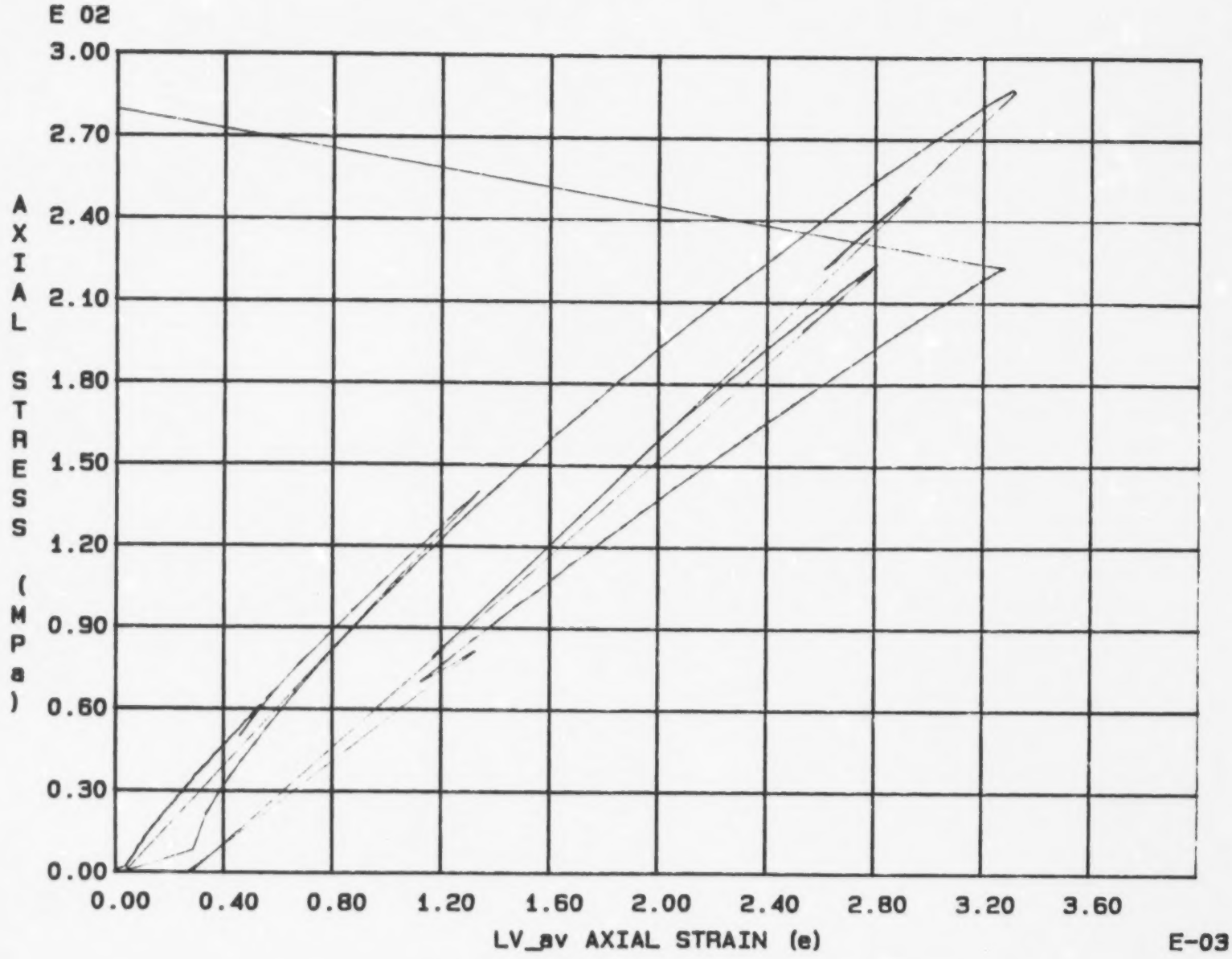

E 02
3.00
2.70
2.40
2.10
1.80
1.50
1.20
0.90
0.60
0.30
0.00
AXIAL STRESS (MPa)
0.00
0.40
0.80
1.20
1.60
2.00
2.40
2.80
3.20
3.60
LV_av AXIAL STRAIN (e)
E-03

Fig. A-46 E85U

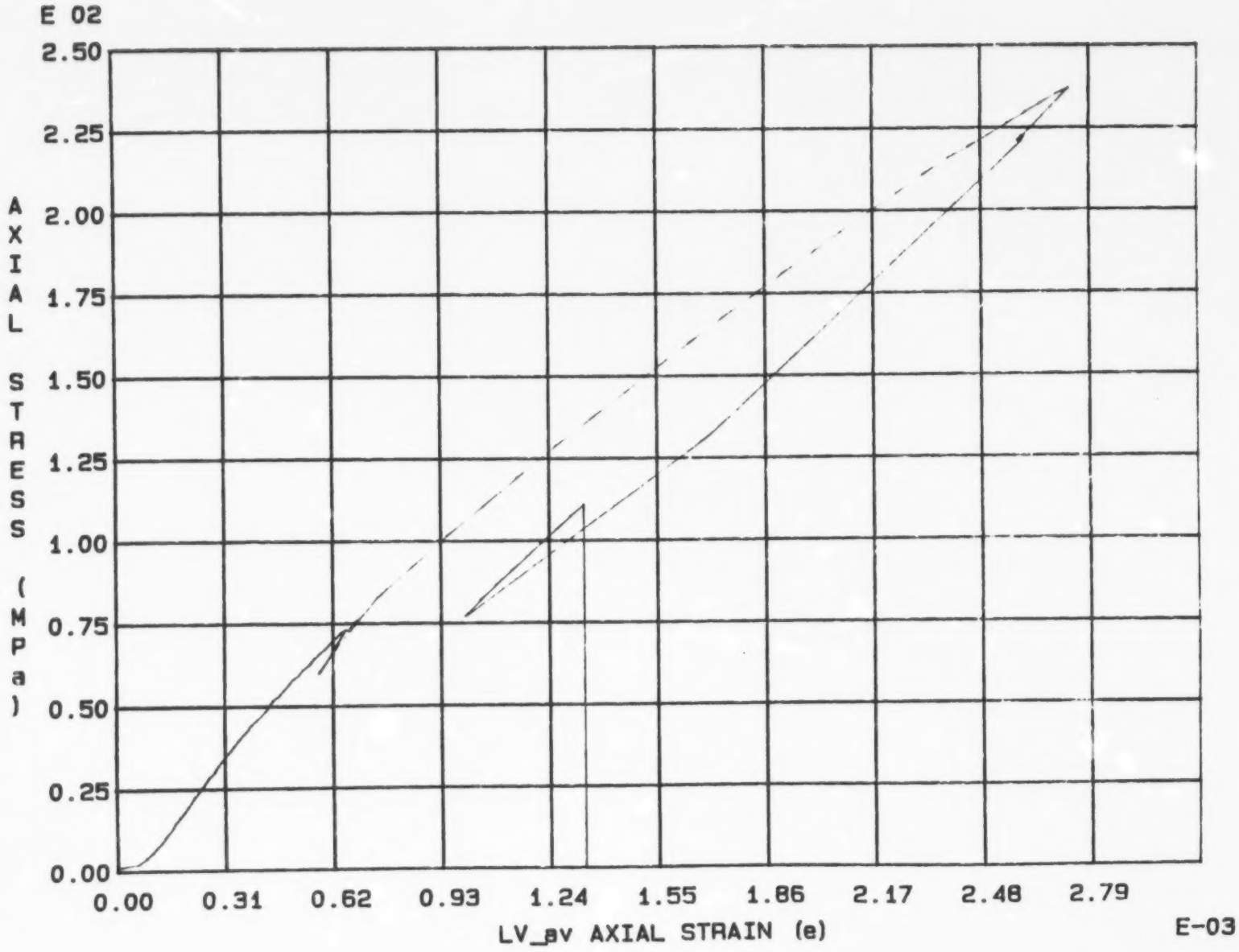

E 02
2.50
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
AXIAL STRESS (MPa)
0.00
0.31
0.62
0.93
1.24
1.55
1.86
2.17
2.48
2.79
LV_av AXIAL STRAIN (e)
E-03

Fig. A-47 E86U

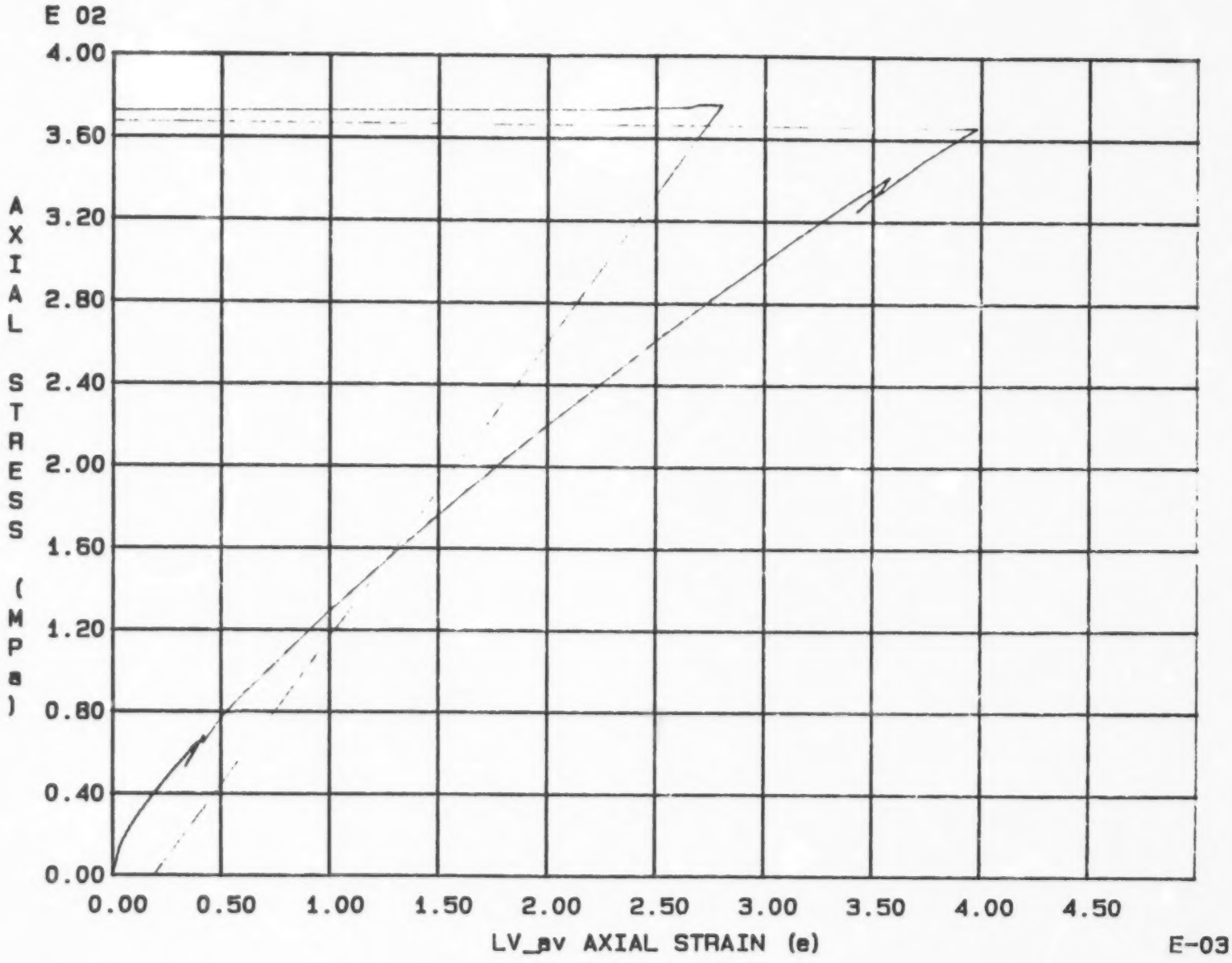

E 02
4.00
3.60
3.20
2.80
2.40
2.00
1.60
1.20
0.80
0.40
0.00
AXIAL STRESS (MPa)
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
LV_av AXIAL STRAIN (e)
E-03

Fig. A-48 E87U

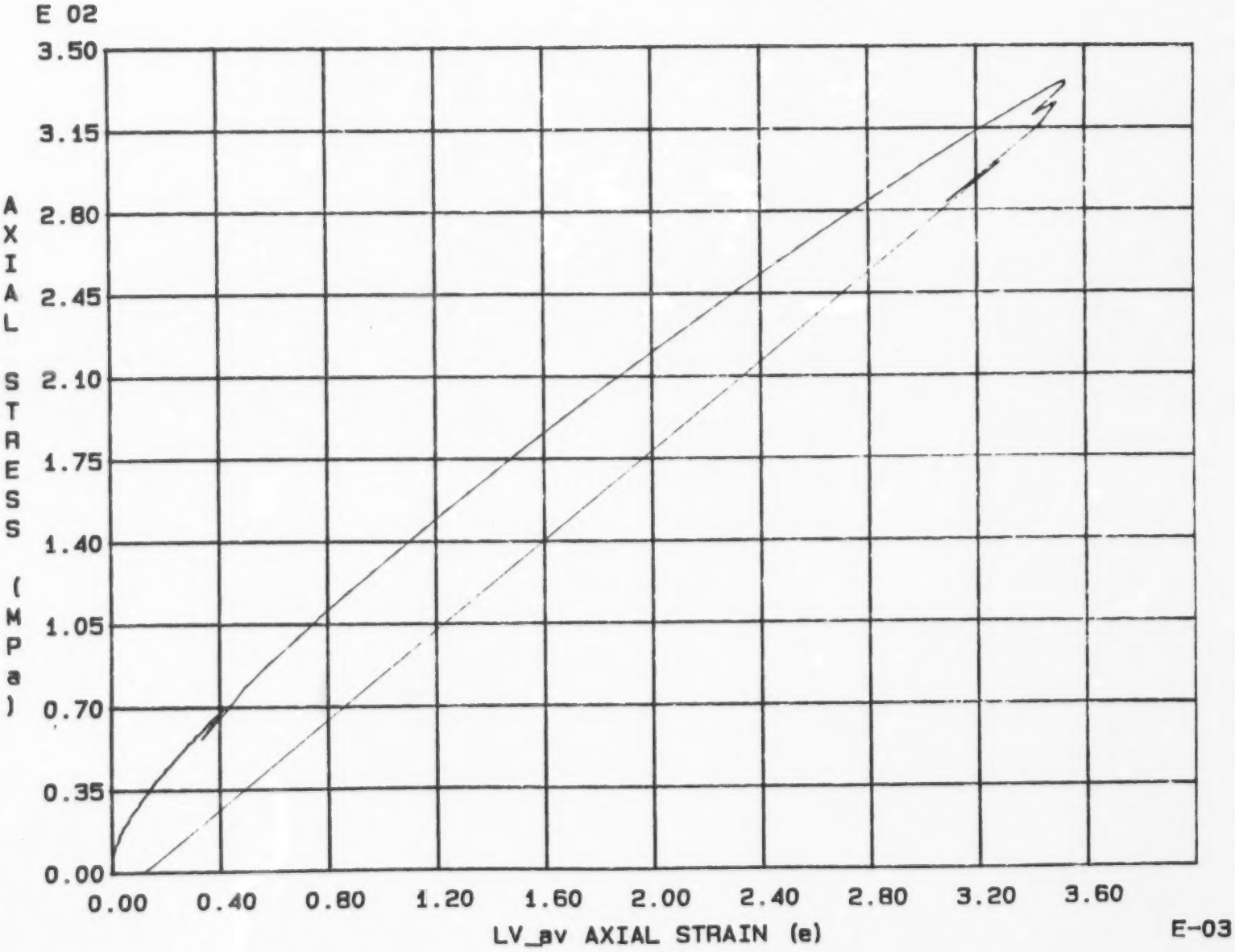

E 02
3.50
3.15
2.80
2.45
2.10
1.75
1.40
1.05
0.70
0.35
0.00
AXIAL STRESS (MPa)
0.00
0.40
0.80
1.20
1.60
2.00
2.40
2.80
3.20
3.60
LV_av AXIAL STRAIN (e)
E-03

Fig. A-49 E88U

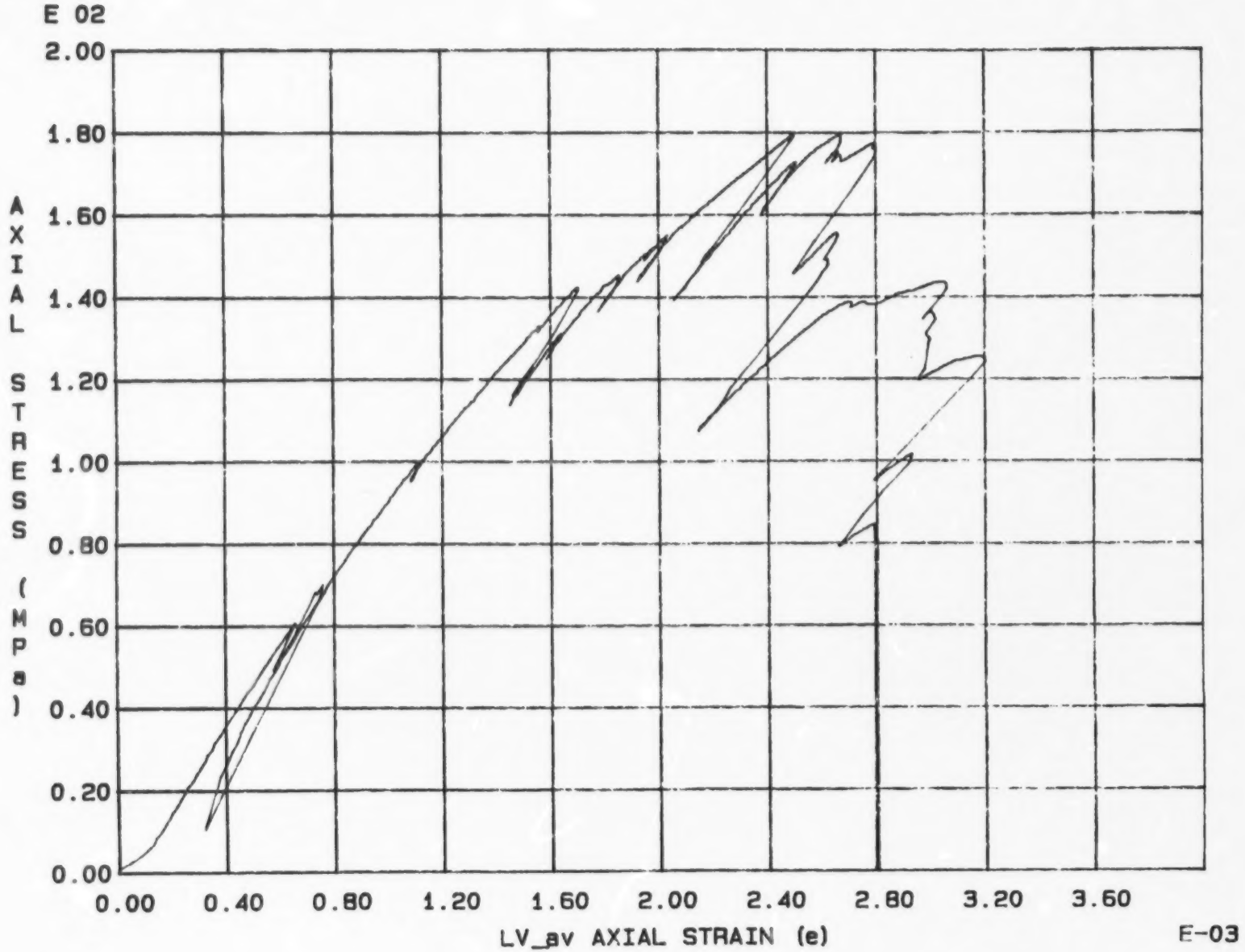

E 02
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
AXIAL STRESS (MPa)
0.00
0.40
0.80
1.20
1.60
2.00
2.40
2.80
3.20
3.60
LV_av AXIAL STRAIN (e)
E-03

Fig. A-50 E89U

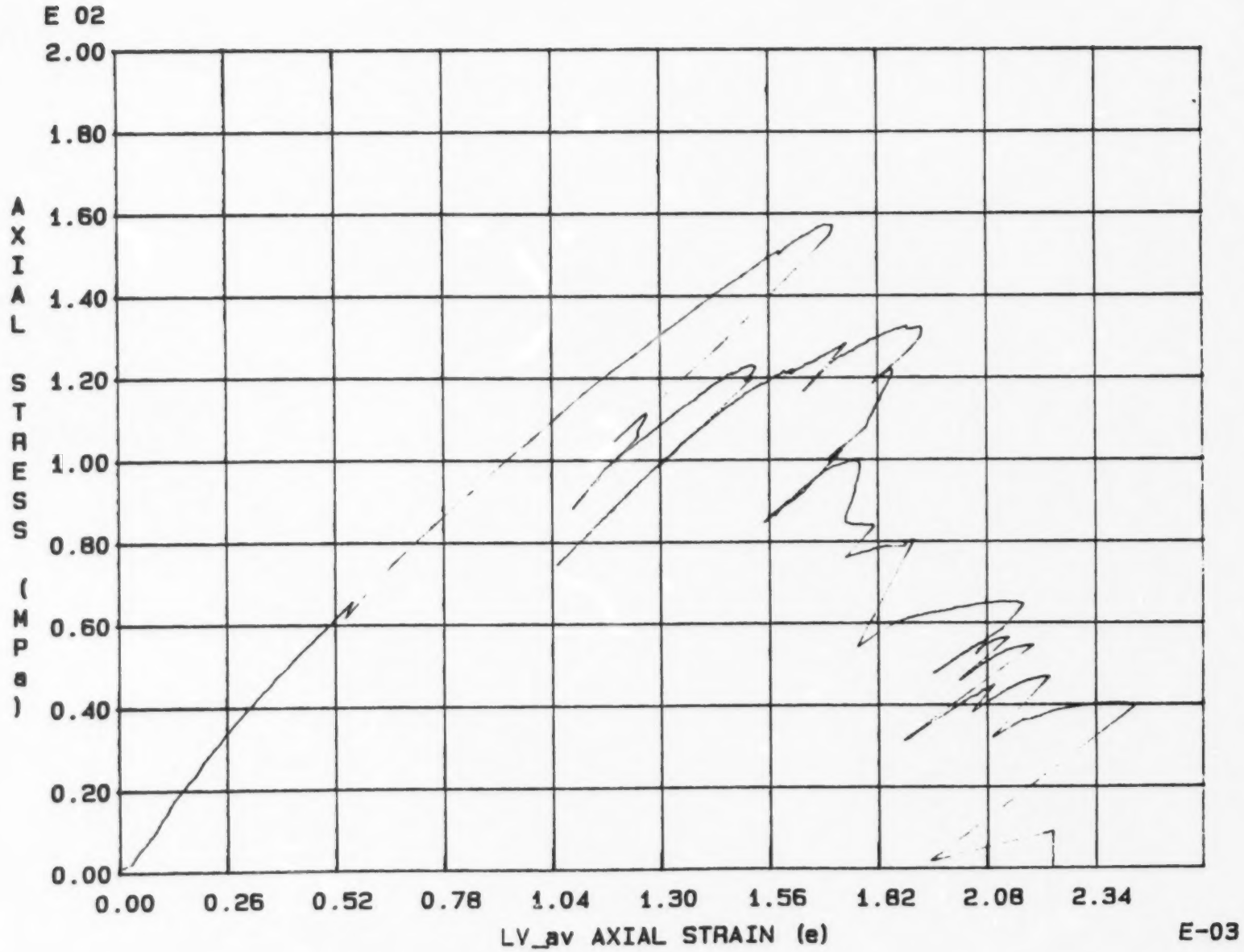

E 02
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
AXIAL STRESS (MPa)
0.00
0.26
0.52
0.78
1.04
1.30
1.56
1.82
2.08
2.34
LV_av AXIAL STRAIN (e)
E-03

Fig. A-51 E90U

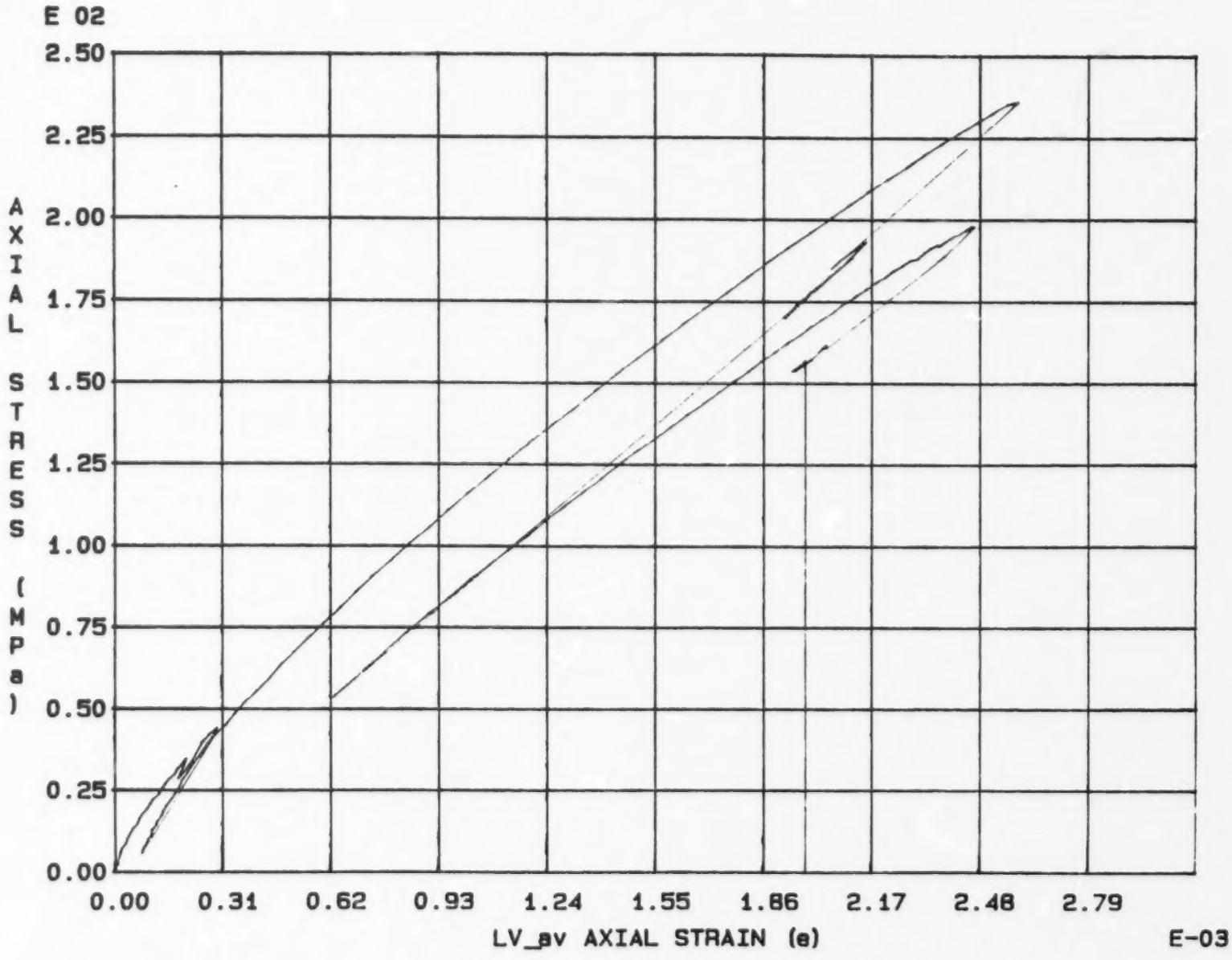

E 02
2.50
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
AXIAL STRESS (MPa)
0.00
0.31
0.62
0.93
1.24
1.55
1.86
2.17
2.48
2.79
LV_av AXIAL STRAIN (e)
E-03

Fig. A-52 E91U

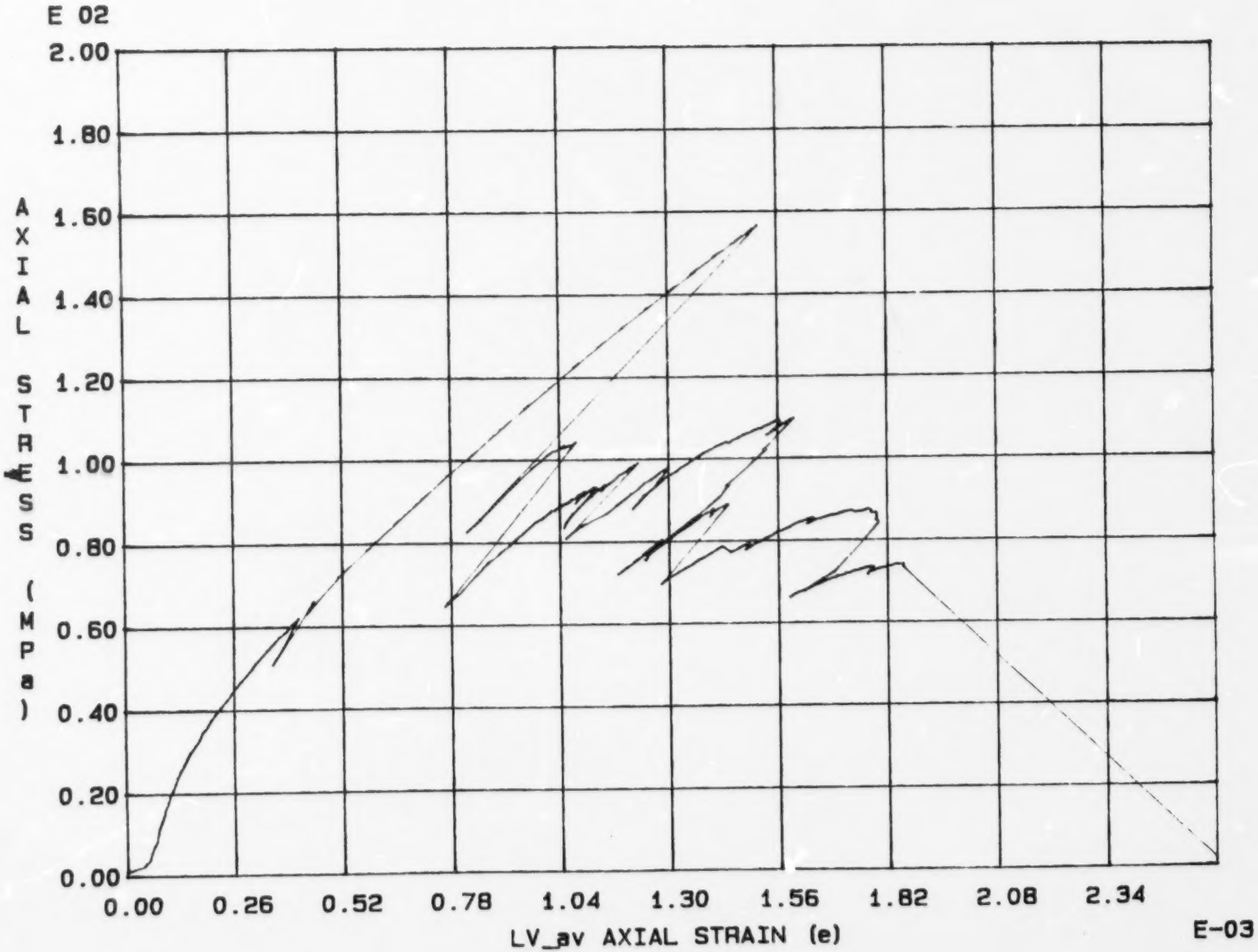


Fig. A-53 E103U

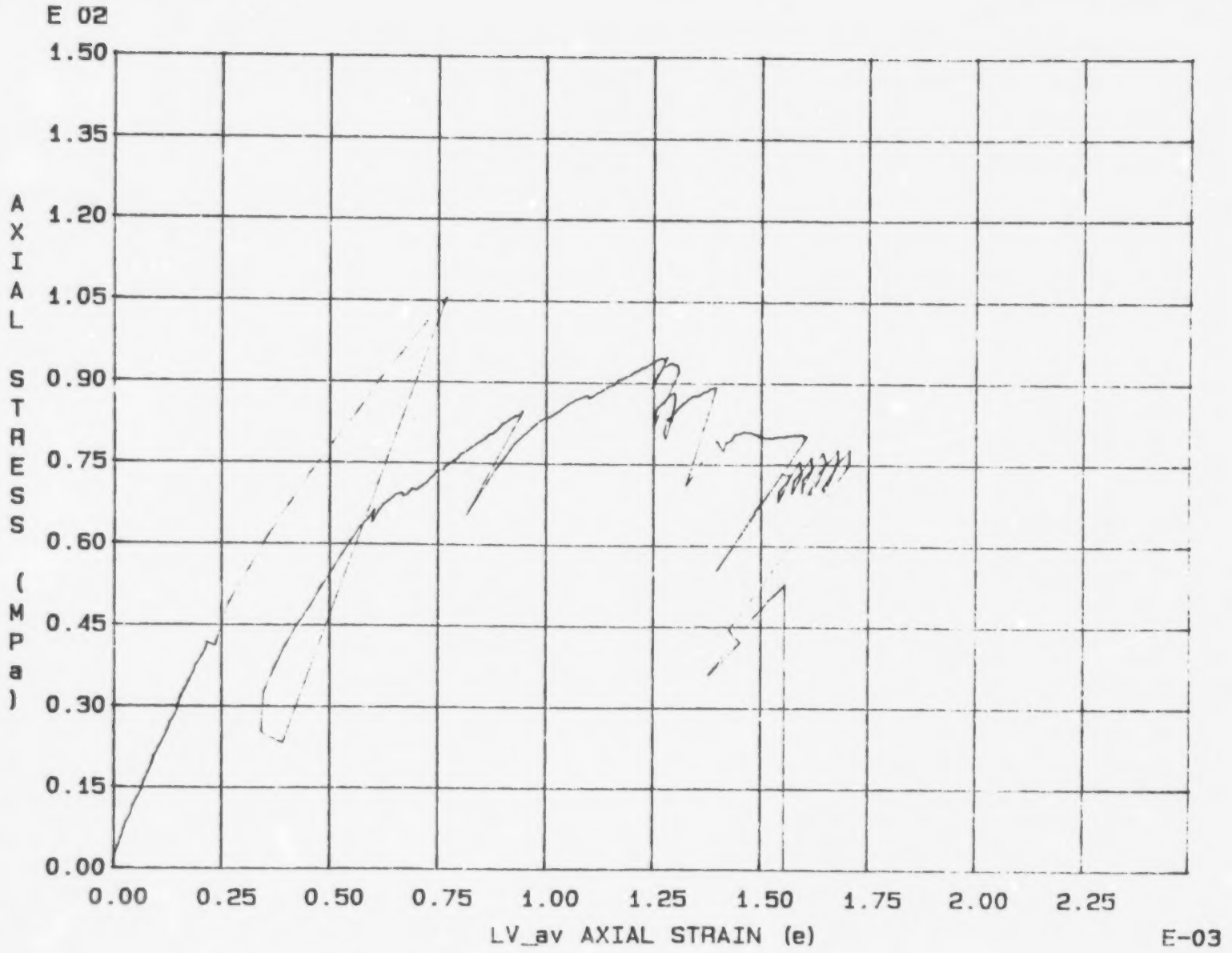


Fig. A-54 E104U

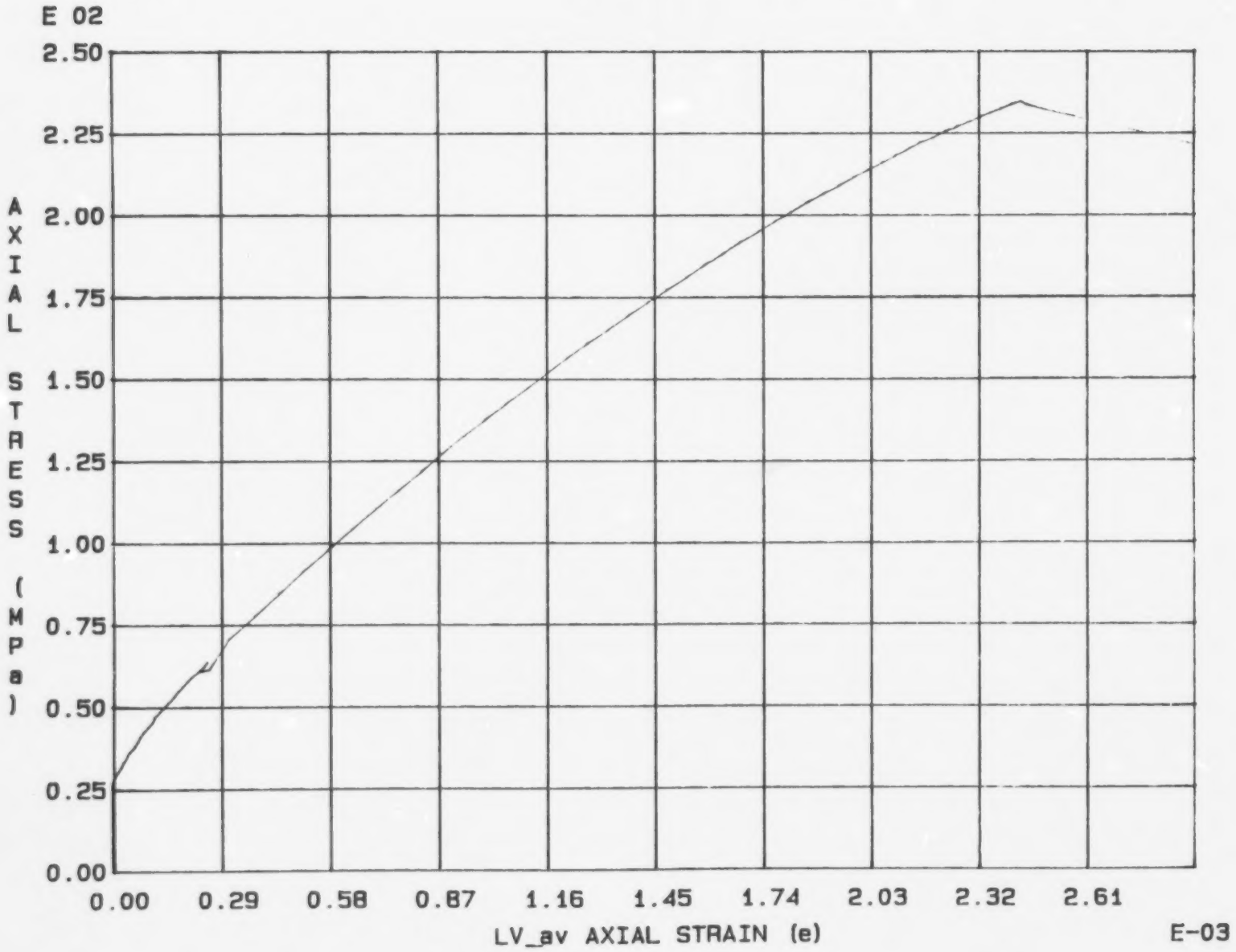


Fig. A-55 E105U

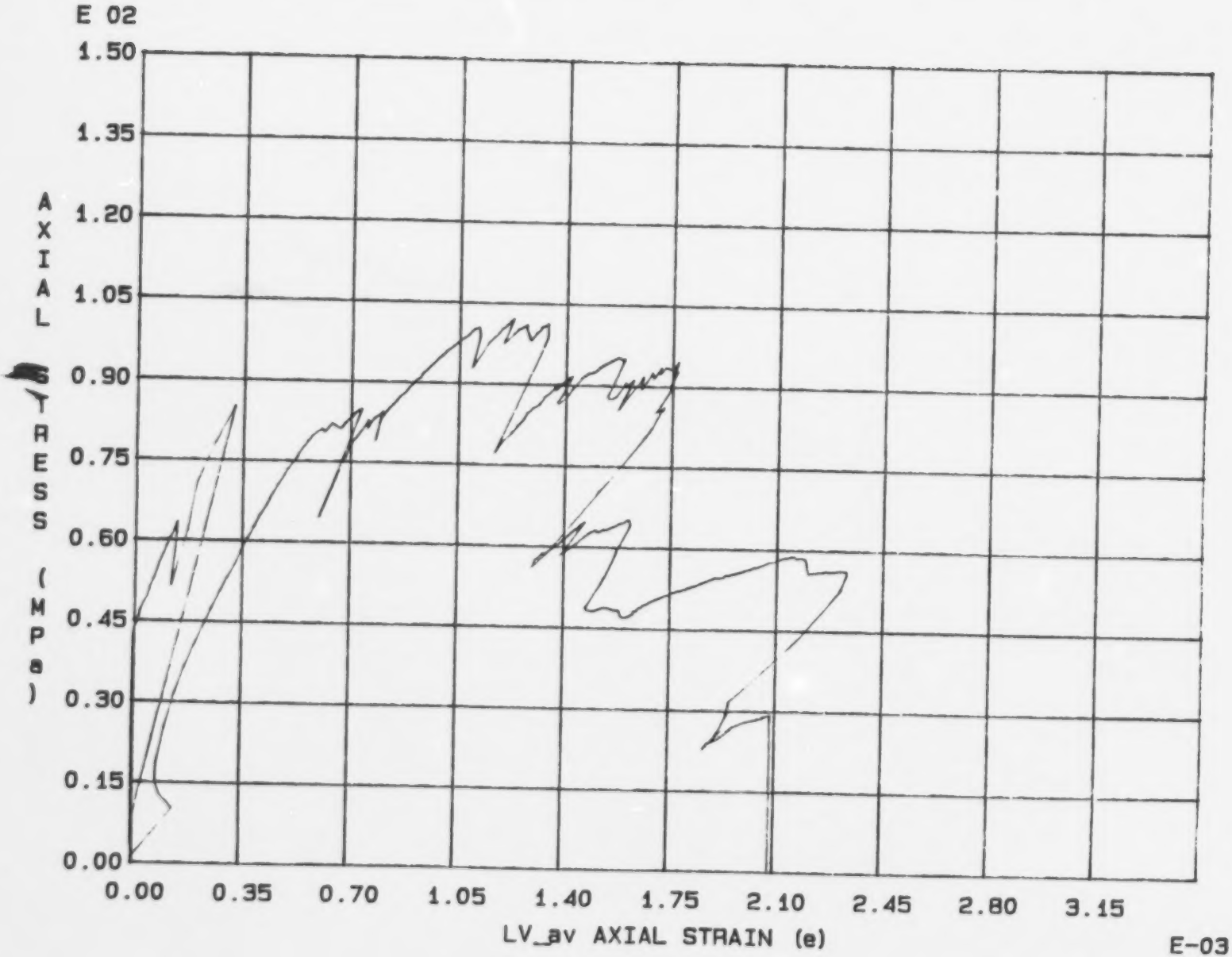


Fig. A-56 E106U

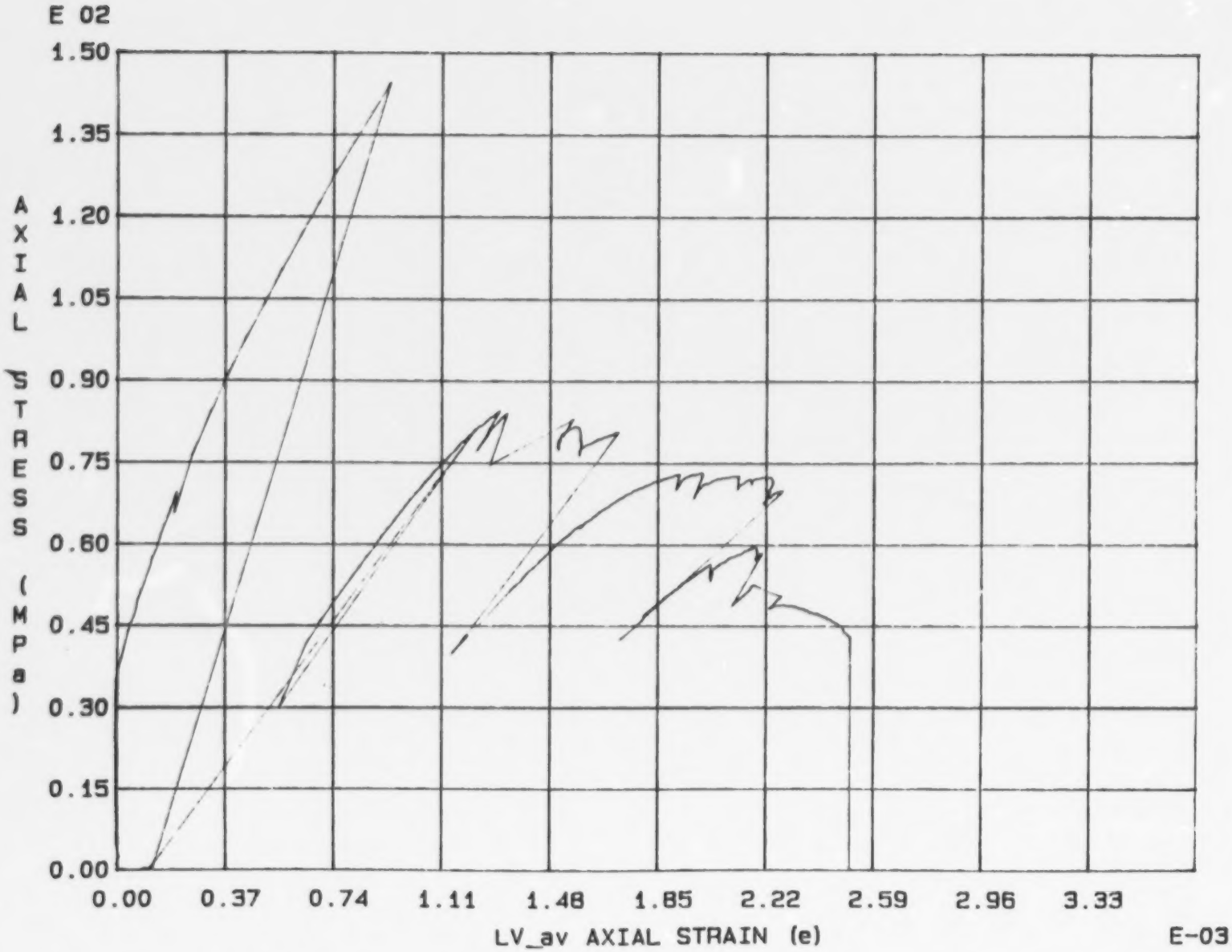


Fig. A-57 E107U

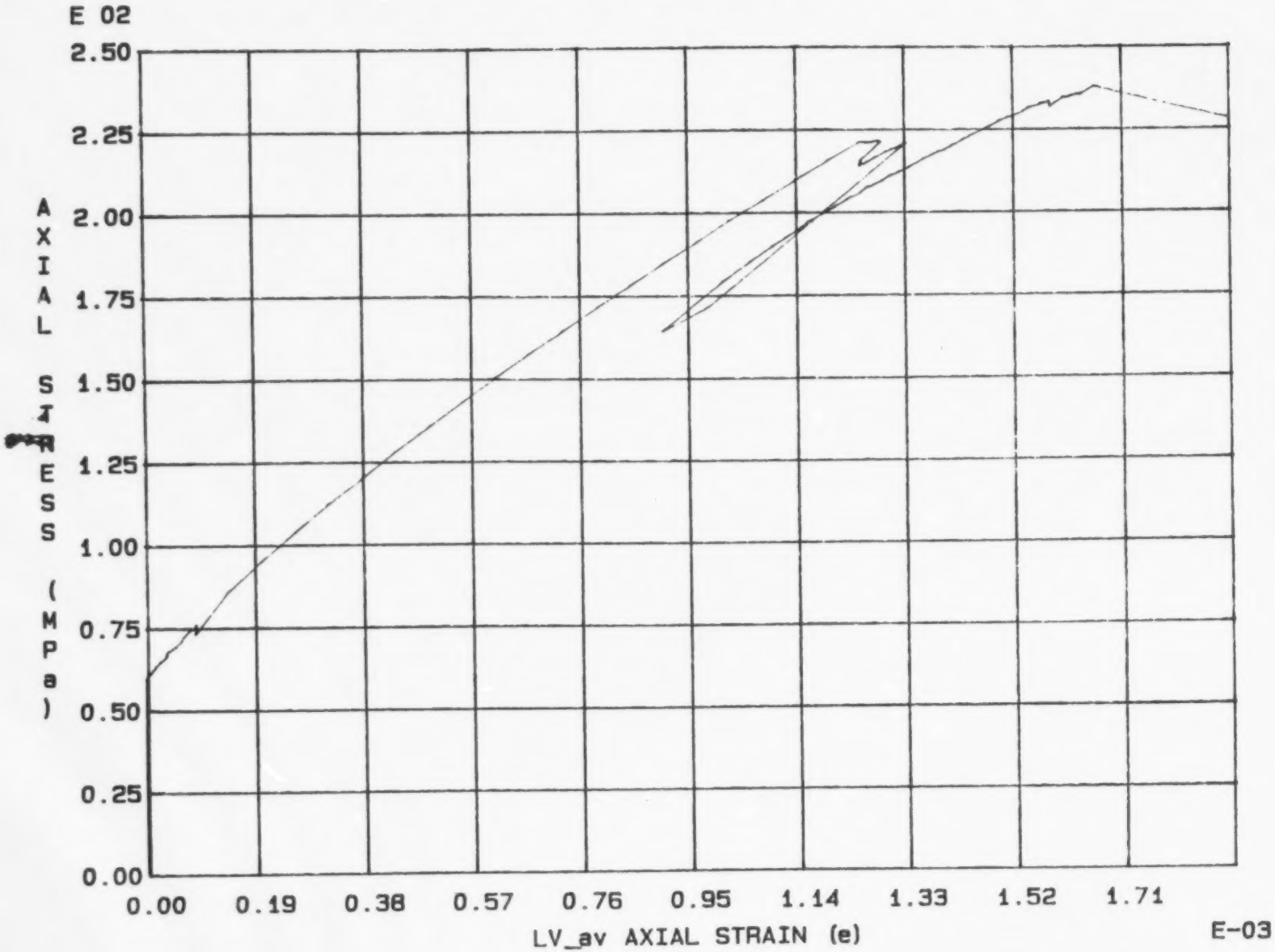


Fig. A-58 E108U

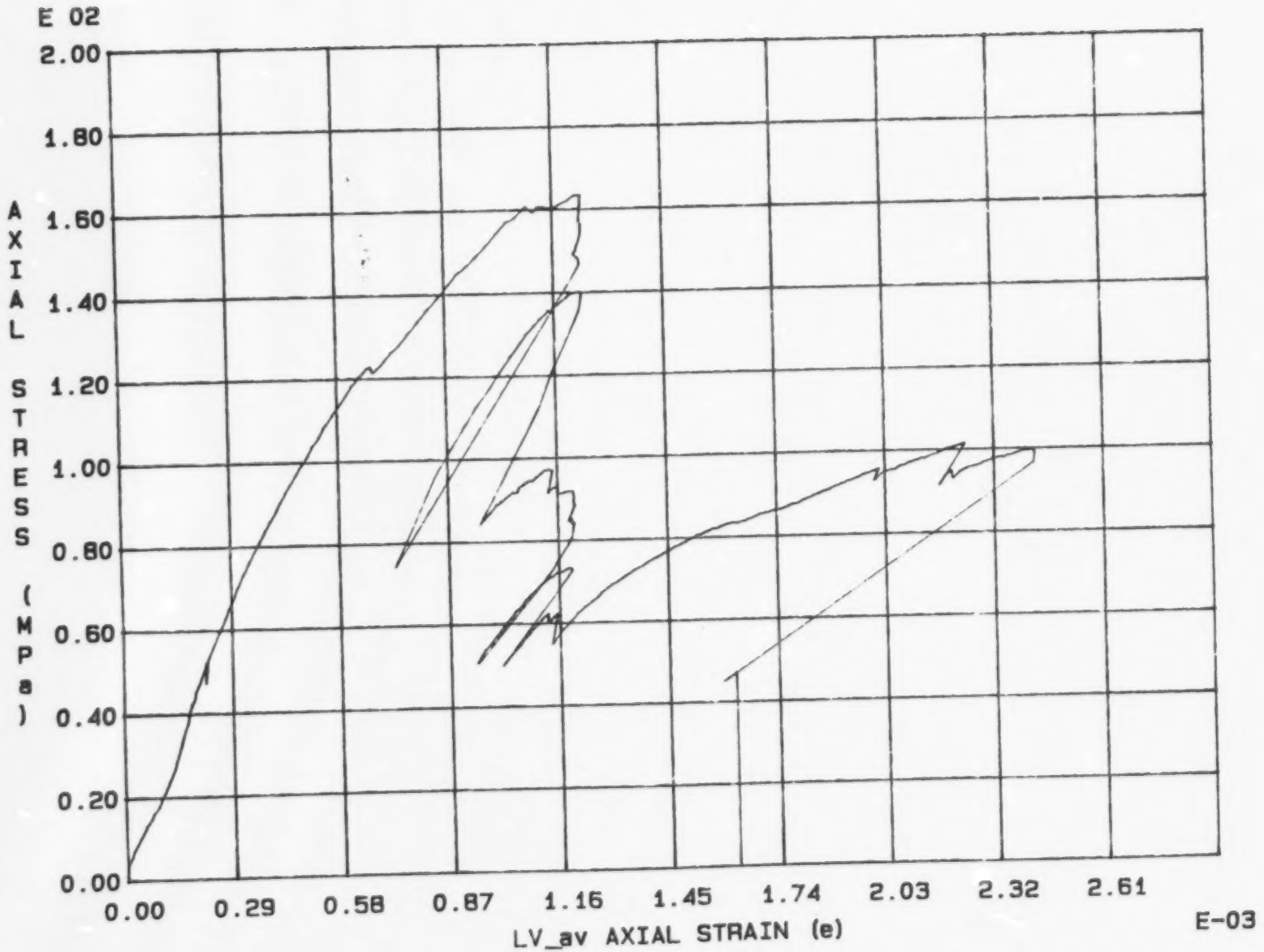


Fig. A-59 E109U

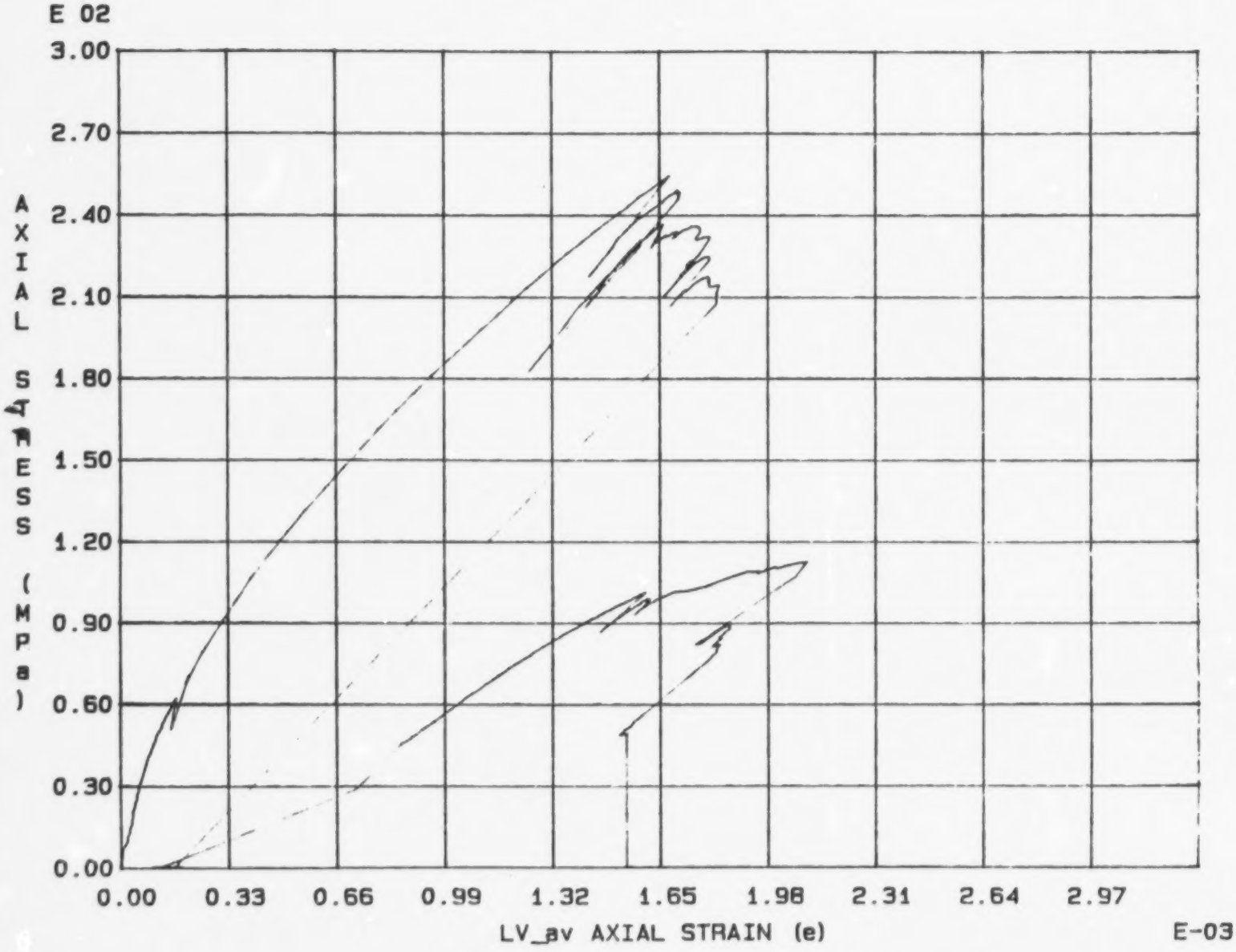


Fig. A-60 E110U

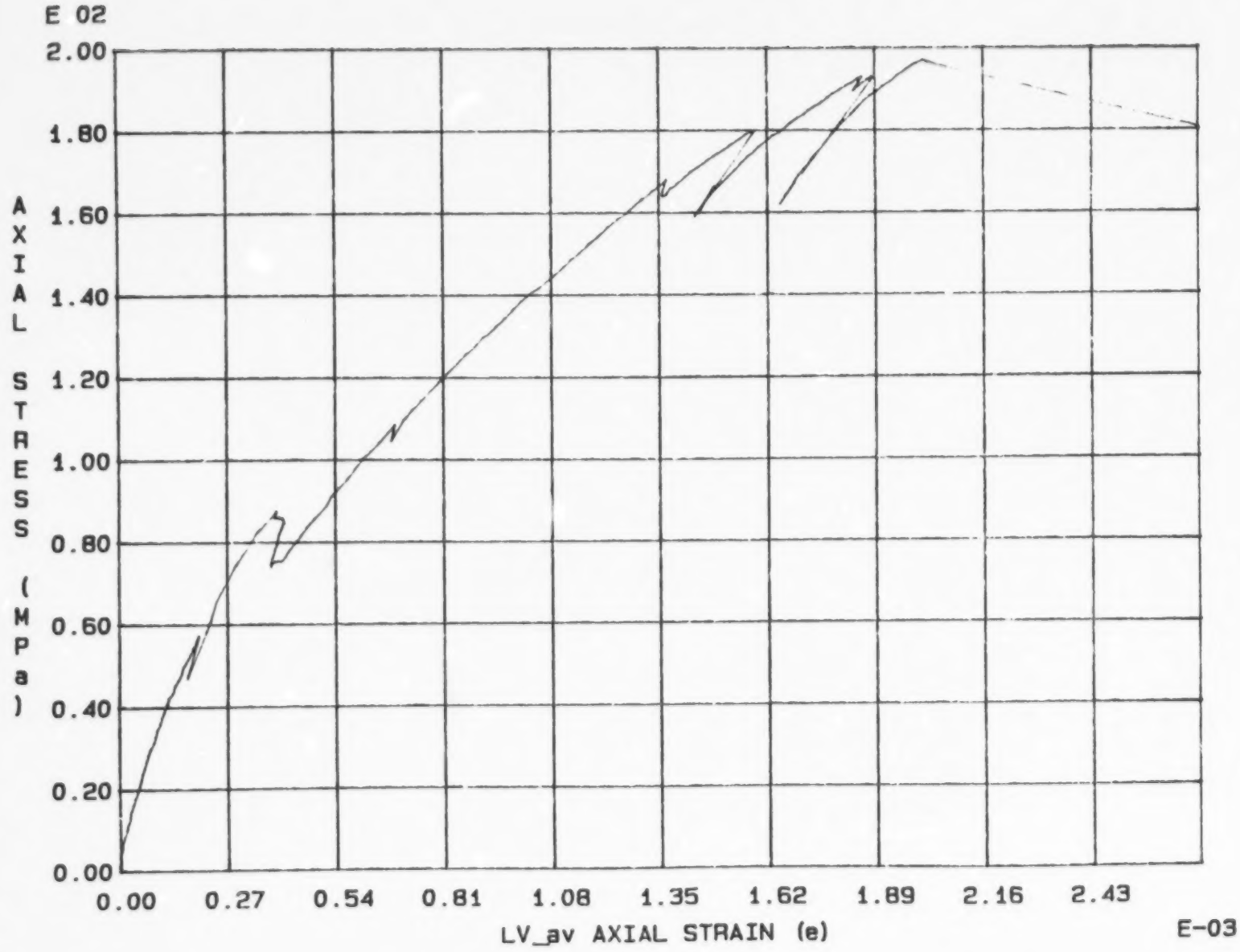


Fig. A-61 E111U

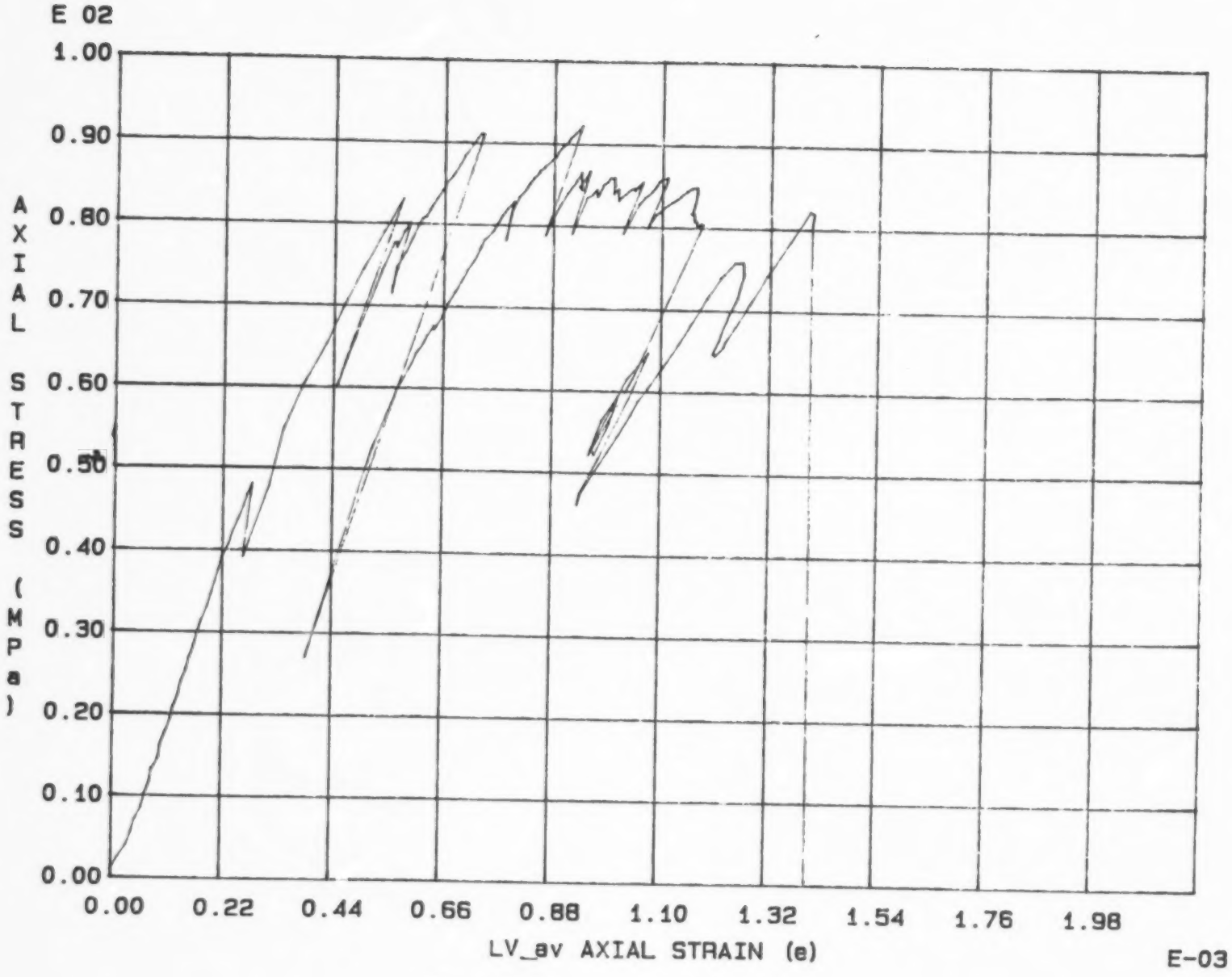


Fig. A-62 E112U

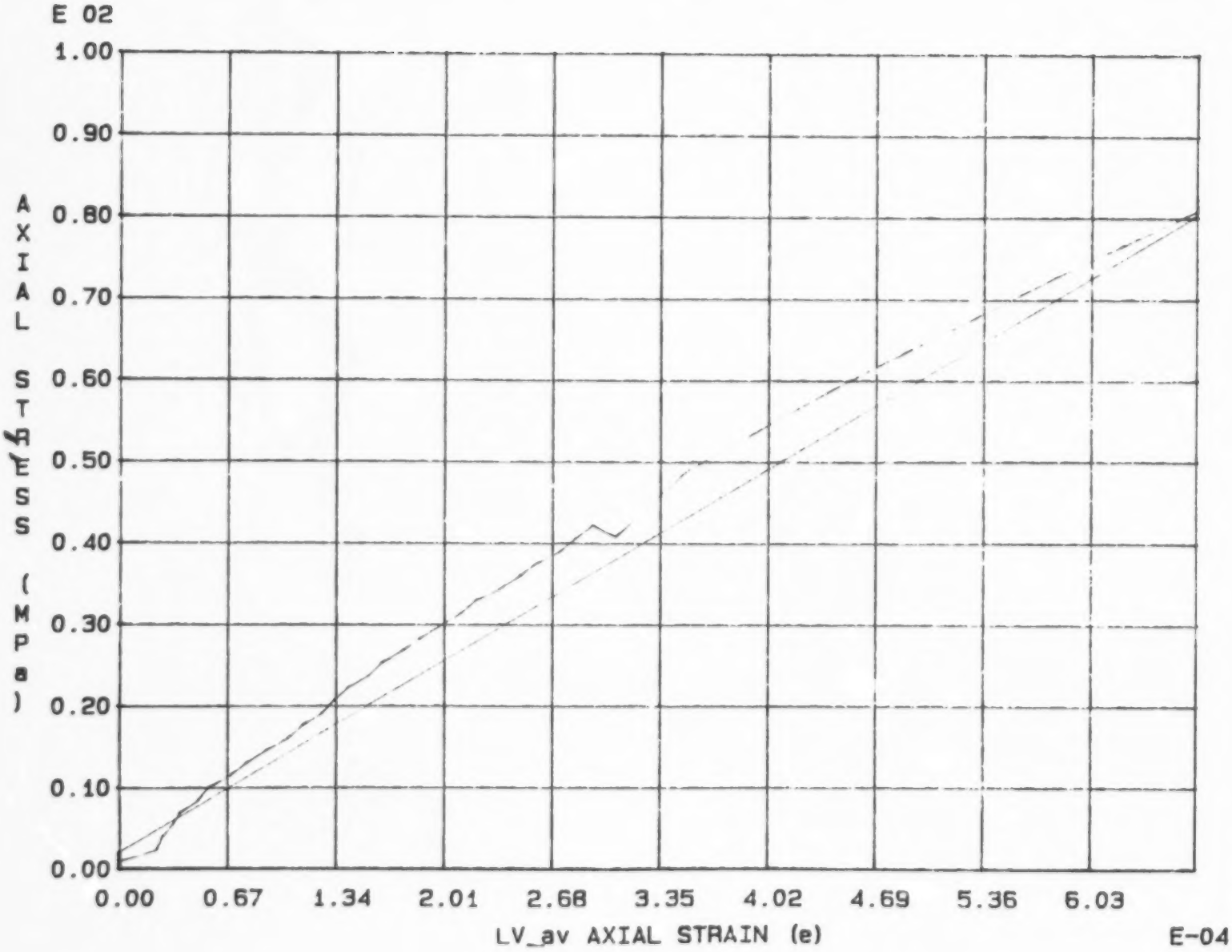


Fig. A-63 E113U

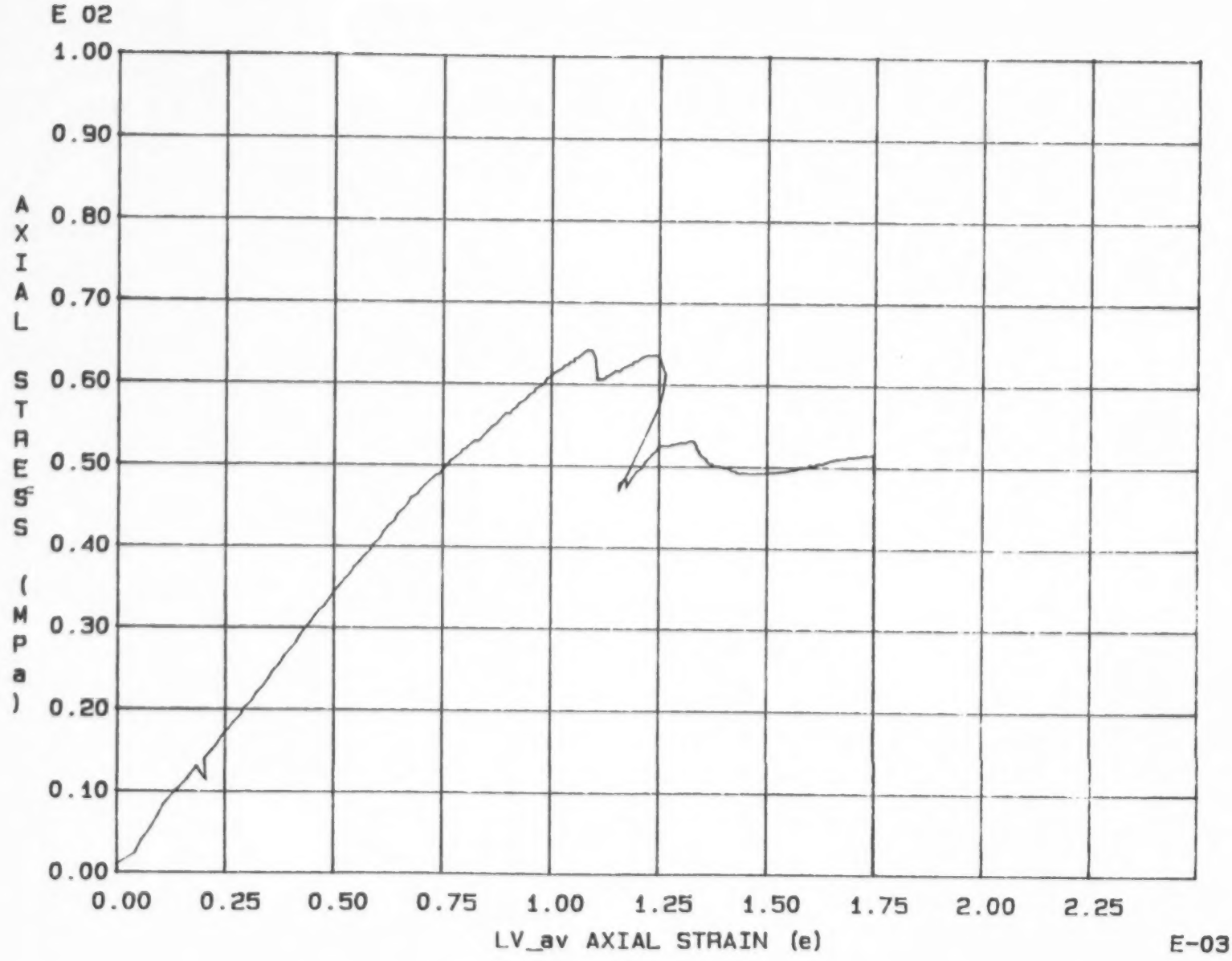


Fig. A-64 E114U

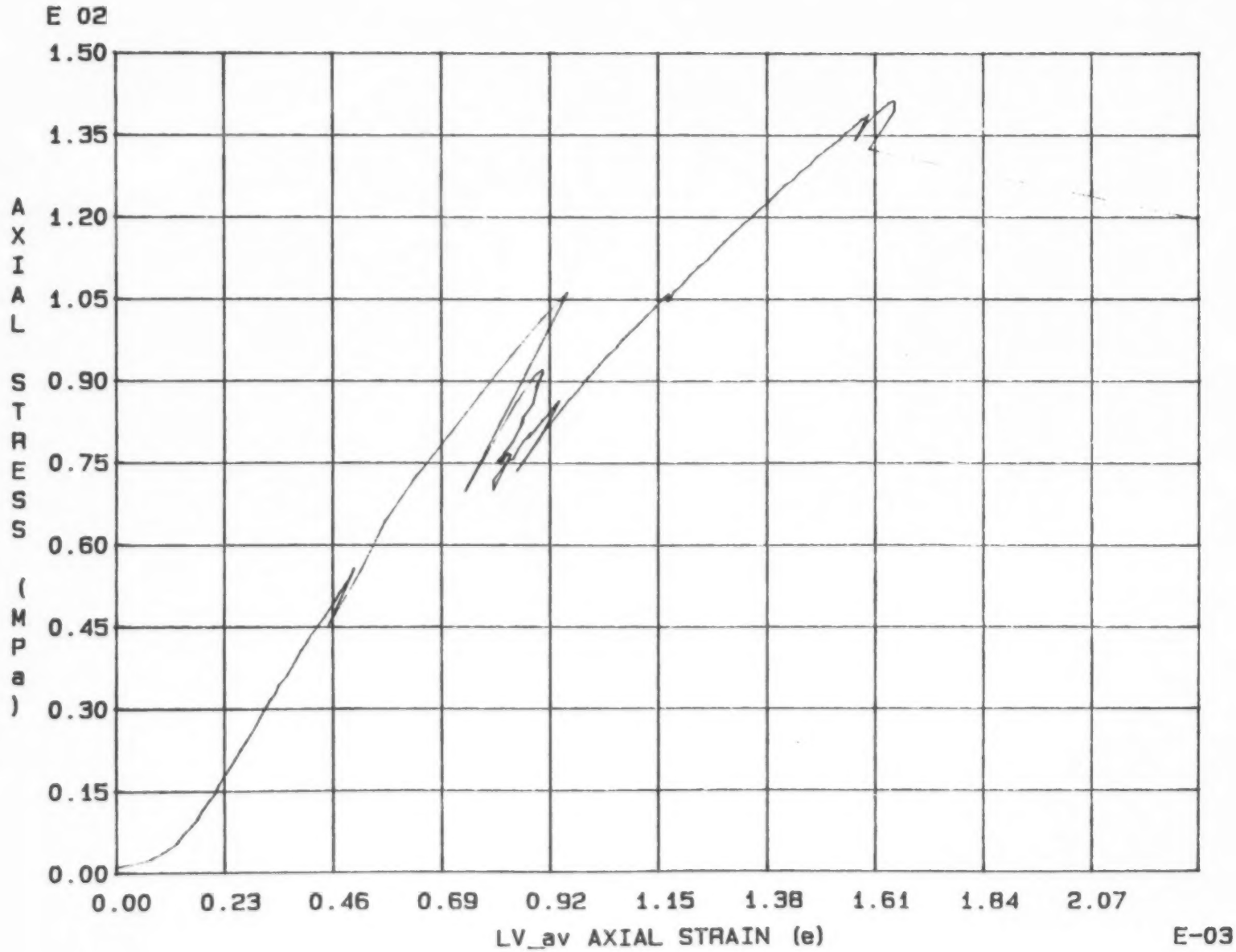


Fig. A-65 E115U

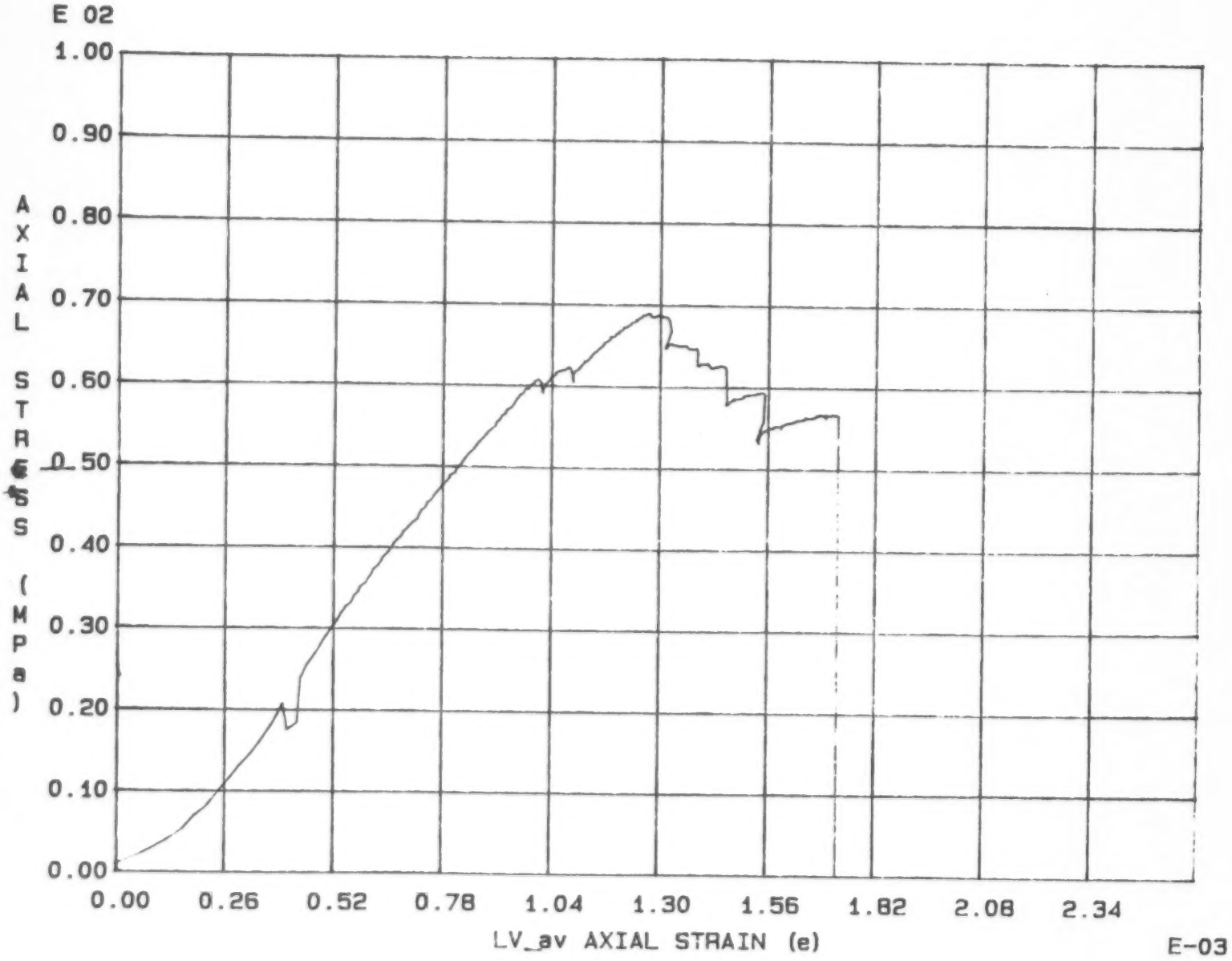


Fig. A-66 E116U

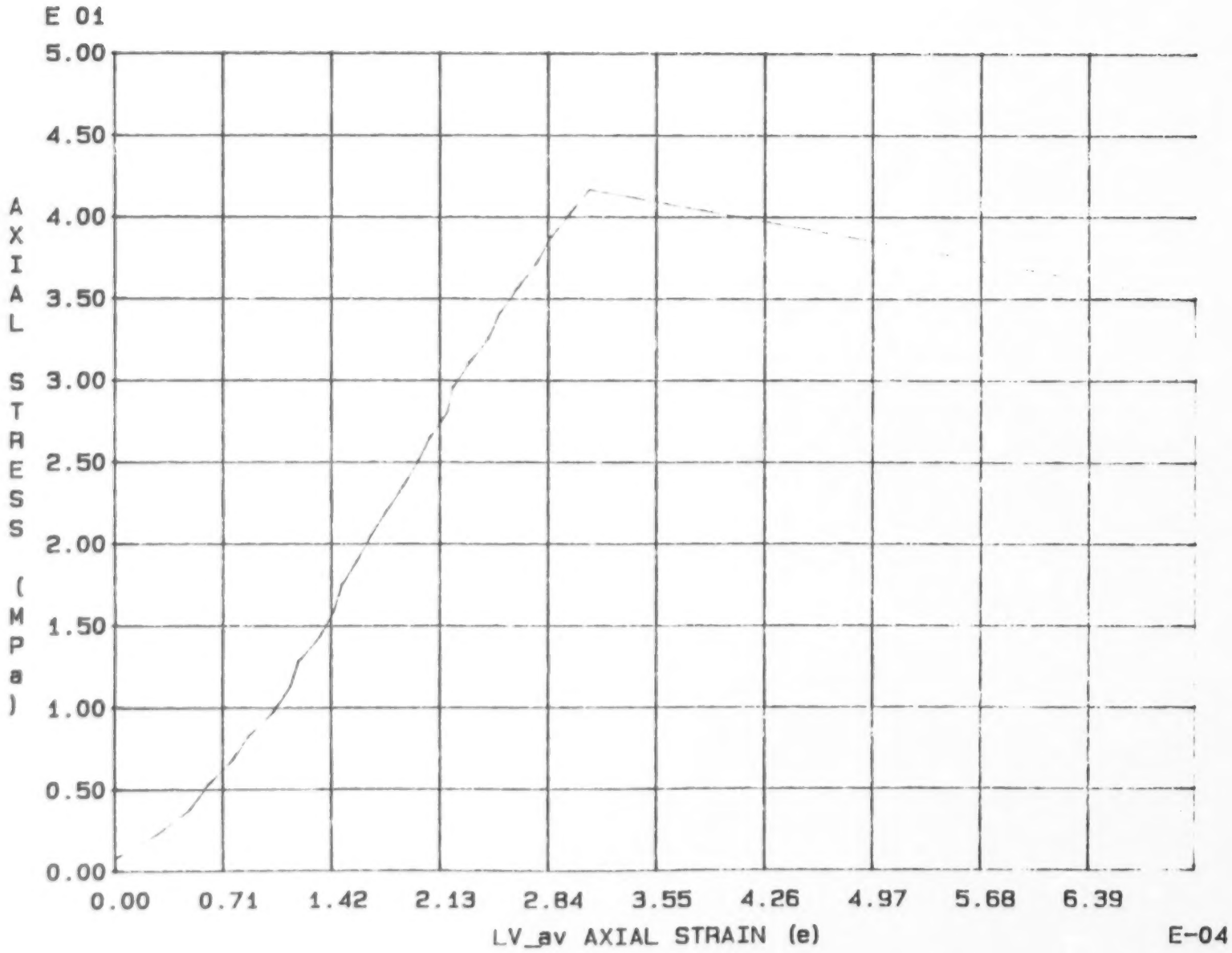


Fig. A-67 E117U

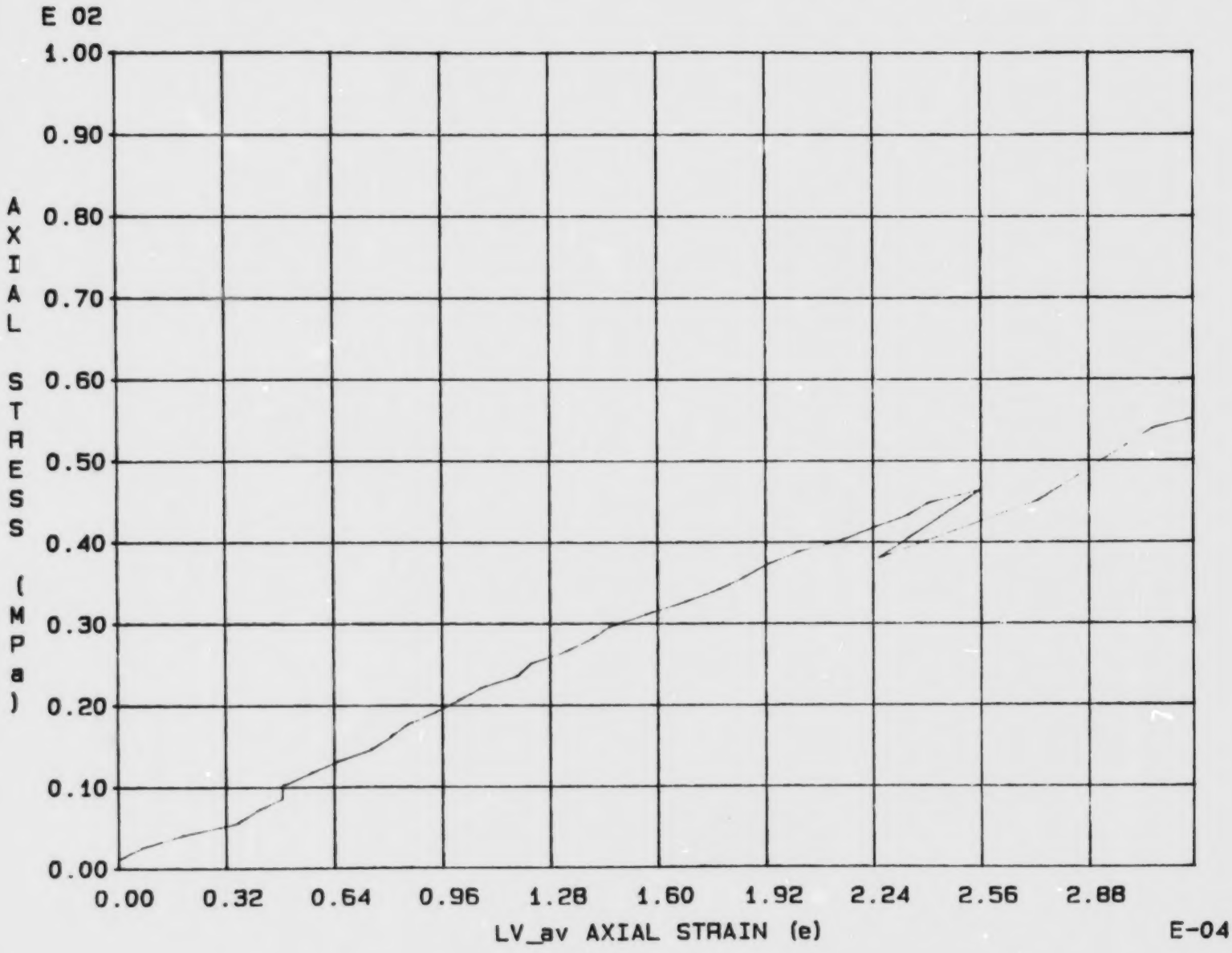


Fig. A-68 E118U

APPENDIX B

STRESS-STRAIN CURVES OF UNIAXIAL TESTS USING CIRCUMFERENTIAL EXTENSOMETER

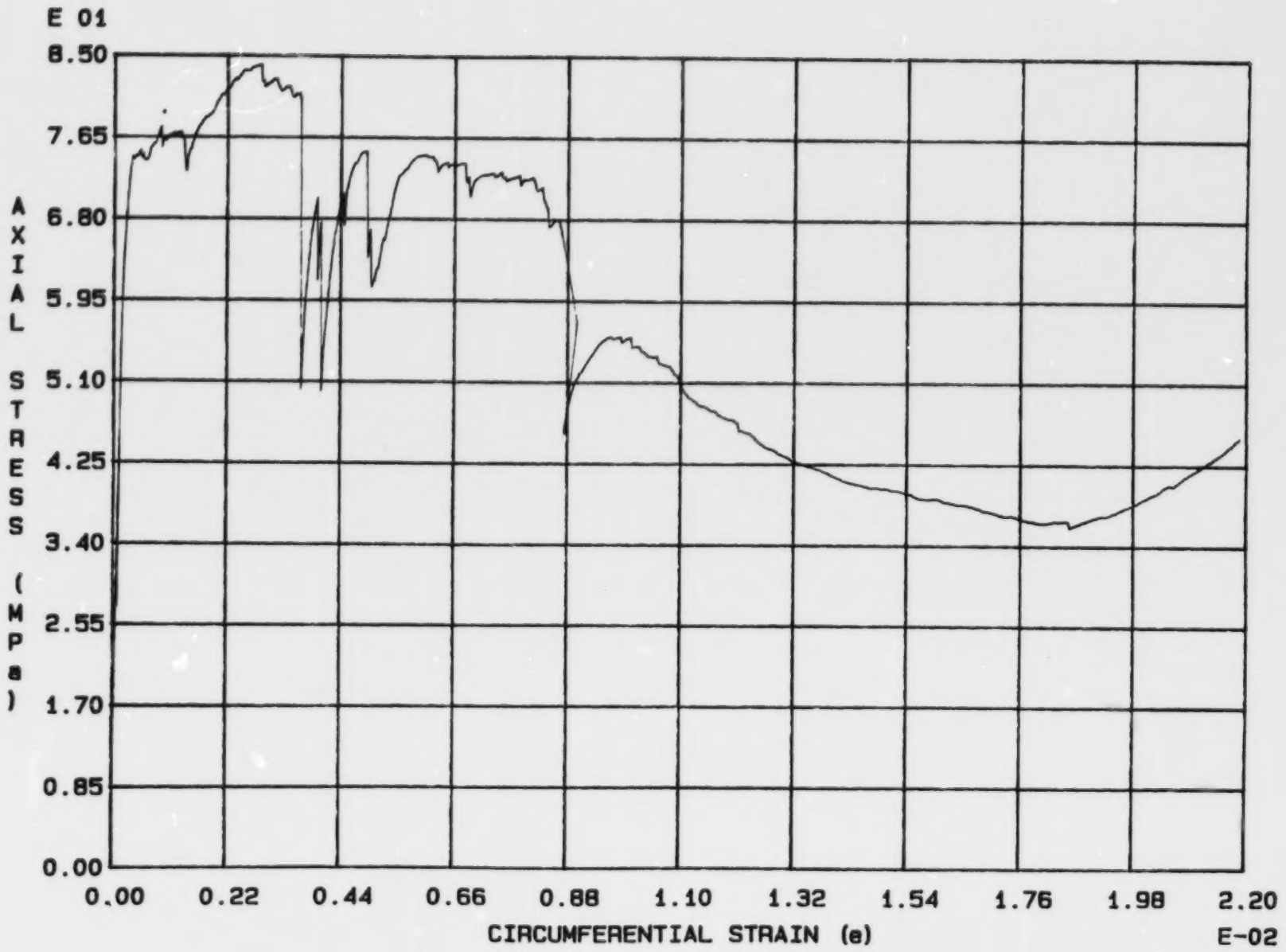

E 01
8.50
7.65
6.80
5.95
5.10
4.25
3.40
2.55
1.70
0.85
0.00
AXIAL STRESS (MPa)
0.00
0.22
0.44
0.66
0.88
1.10
1.32
1.54
1.76
1.98
2.20
CIRCUMFERENTIAL STRAIN (e)
E-02

Fig. B-1 E1U

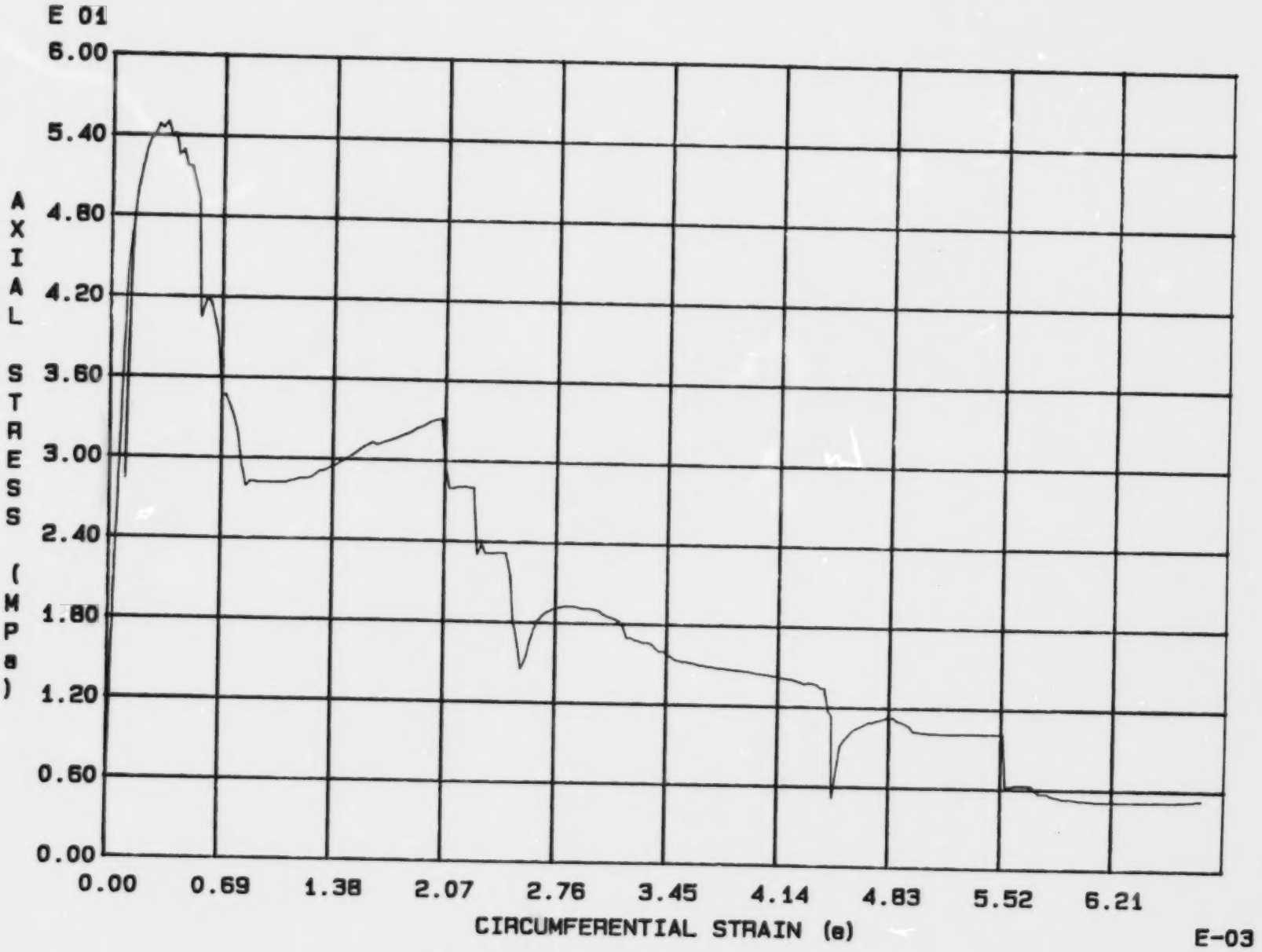

E 01
6.00
5.40
4.80
4.20
3.60
3.00
2.40
1.80
1.20
0.60
0.00
AXIAL STRESS (MPa)
0.00
0.69
1.38
2.07
2.76
3.45
4.14
4.83
5.52
6.21
CIRCUMFERENTIAL STRAIN (e)
E-03

Fig. B-2 E3U

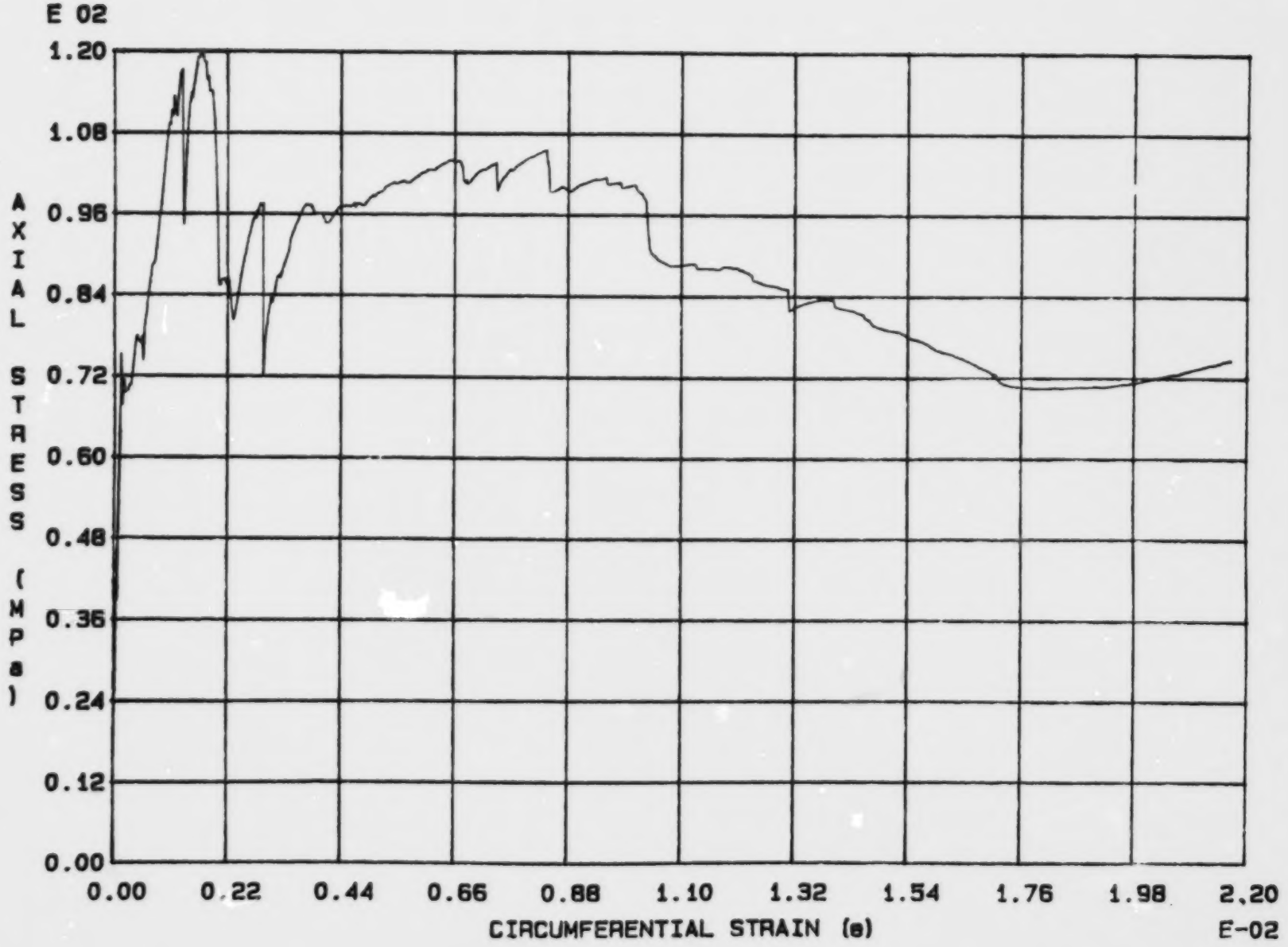

E 02
1.20
1.08
0.96
0.84
0.72
0.60
0.48
0.36
0.24
0.12
0.00
AXIAL STRESS (MPa)
0.00
0.22
0.44
0.66
0.88
1.10
1.32
1.54
1.76
1.98
2.20
CIRCUMFERENTIAL STRAIN (e)
E-02

Fig. B-3 E5U

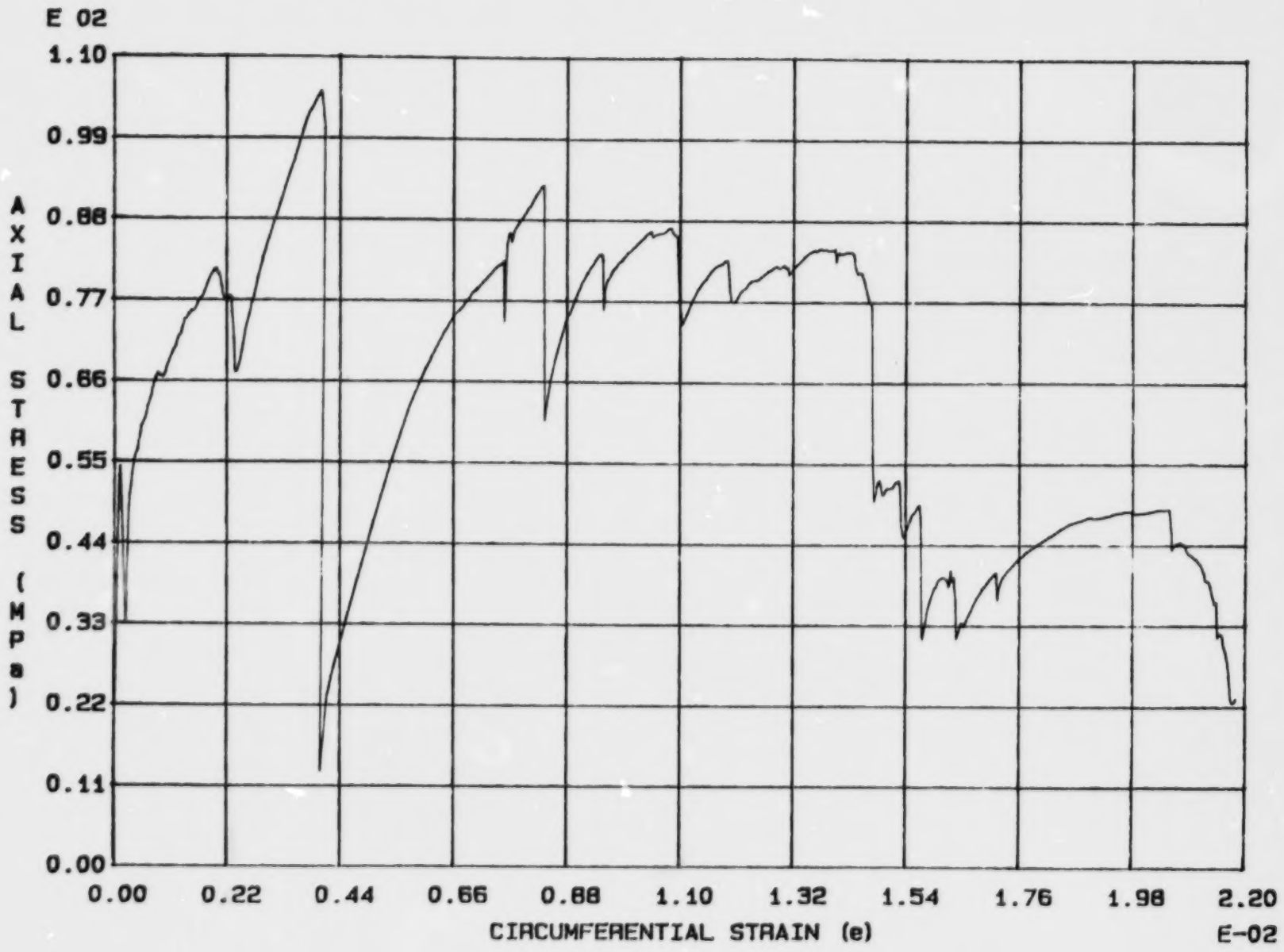

E 02
1.10
0.99
0.88
0.77
0.66
0.55
0.44
0.33
0.22
0.11
0.00
AXIAL STRESS (MPa)
0.00
0.22
0.44
0.66
0.88
1.10
1.32
1.54
1.76
1.98
2.20
CIRCUMFERENTIAL STRAIN (e)
E-02

Fig. B-4 E7U

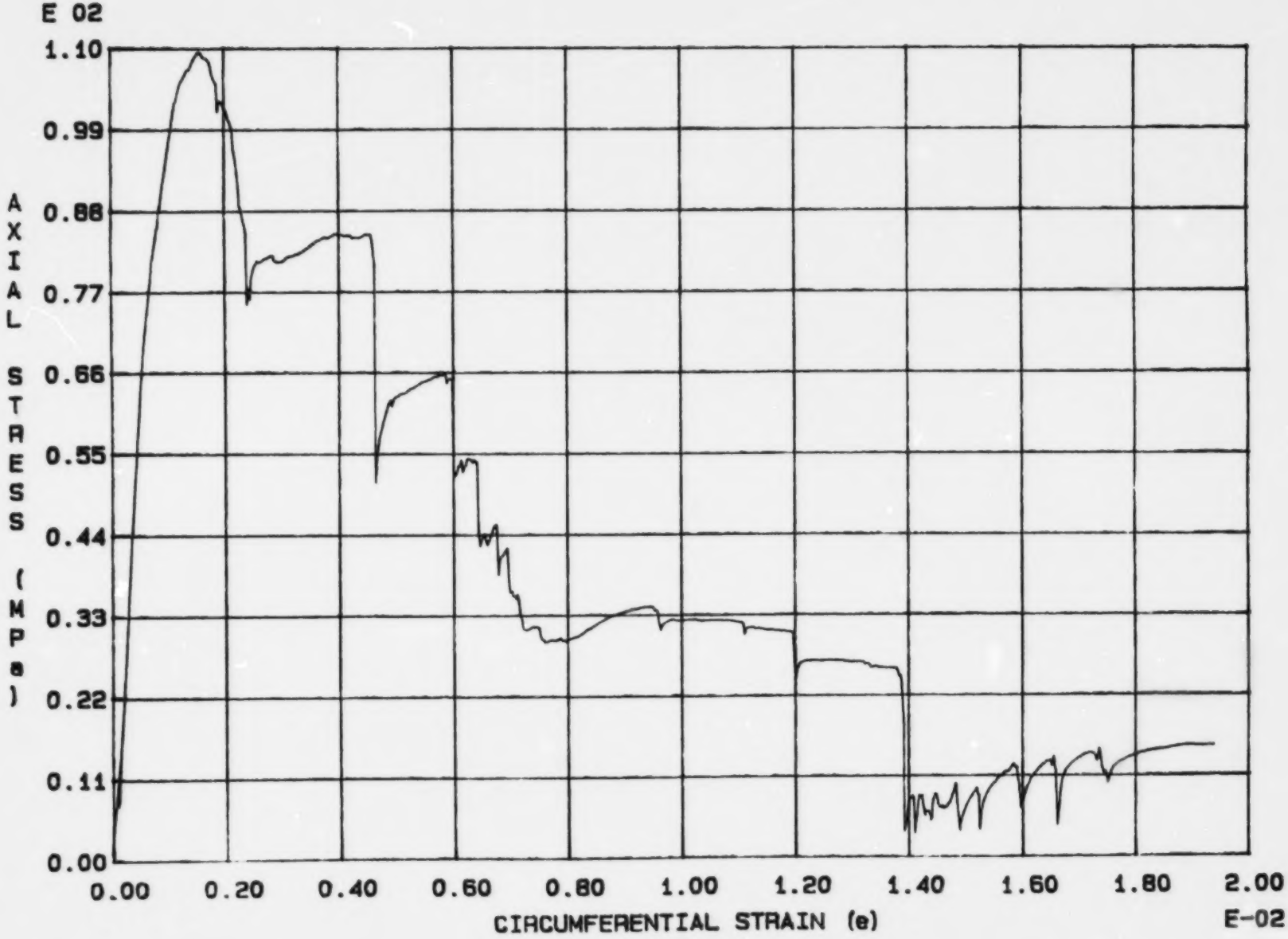

E 02
1.10
0.99
0.88
0.77
0.66
0.55
0.44
0.33
0.22
0.11
0.00
AXIAL STRESS (MPa)
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
1.60
1.80
2.00
CIRCUMFERENTIAL STRAIN (e)
E-02

Fig. B-5 EGUA

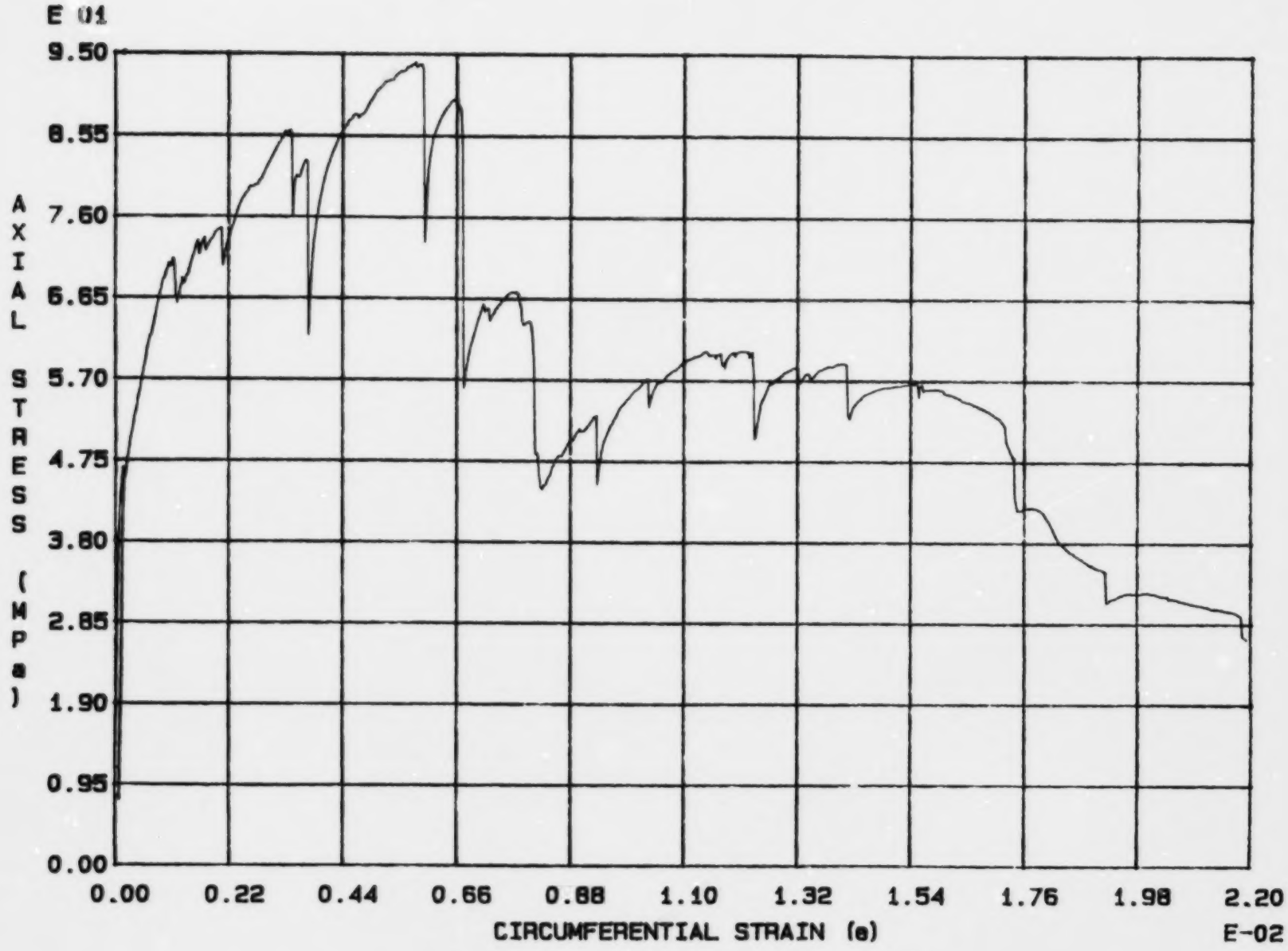

E 01
9.50
8.55
7.60
6.65
5.70
4.75
3.80
2.85
1.90
0.95
0.00
AXIAL STRESS (MPa)
0.00
0.22
0.44
0.66
0.88
1.10
1.32
1.54
1.76
1.98
2.20
CIRCUMFERENTIAL STRAIN (e)
E-02

Fig. B-6 E11U

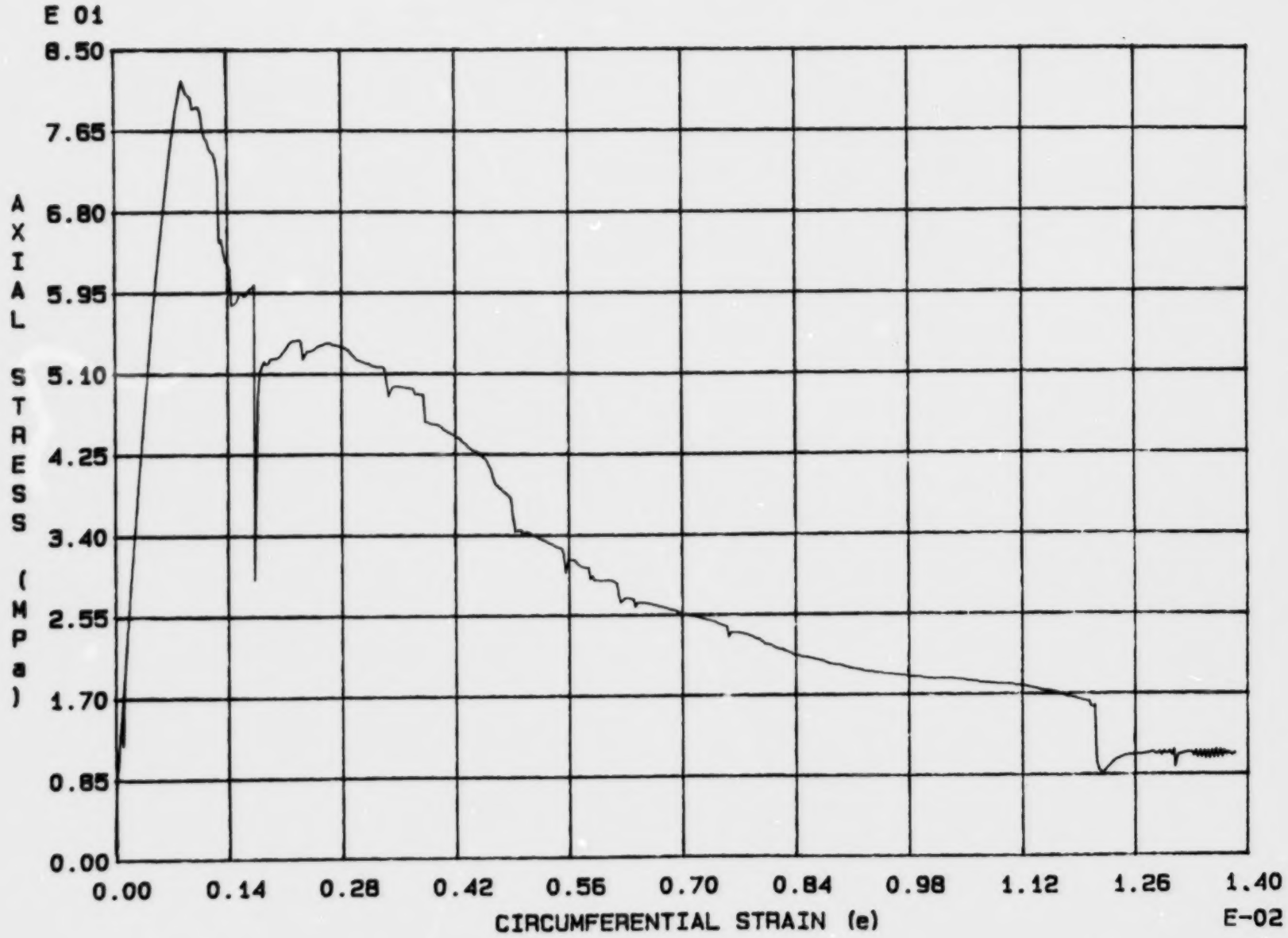

E 01
8.50
7.65
6.80
5.95
5.10
4.25
3.40
2.55
1.70
0.85
0.00
AXIAL STRESS (MPa)
0.00
0.14
0.28
0.42
0.56
0.70
0.84
0.98
1.12
1.26
1.40
E-02
CIRCUMFERENTIAL STRAIN (e)

Fig. B-7 E13U

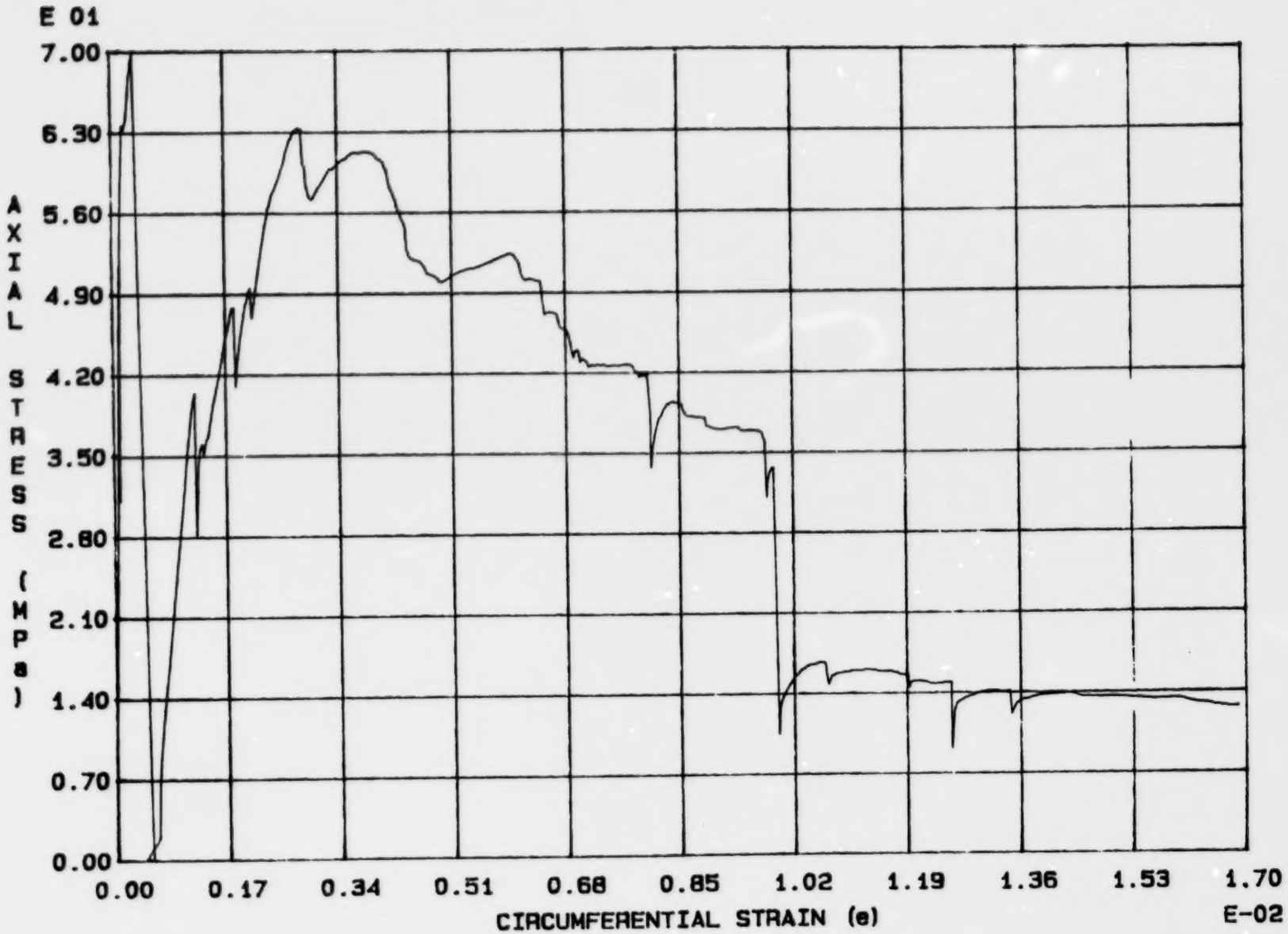

E 01
7.00
6.30
5.60
4.90
4.20
3.50
2.80
2.10
1.40
0.70
0.00
AXIAL STRESS (MPa)
0.00
0.17
0.34
0.51
0.68
0.85
1.02
1.19
1.36
1.53
1.70
CIRCUMFERENTIAL STRAIN (e)
E-02

Fig. B-8 E15U

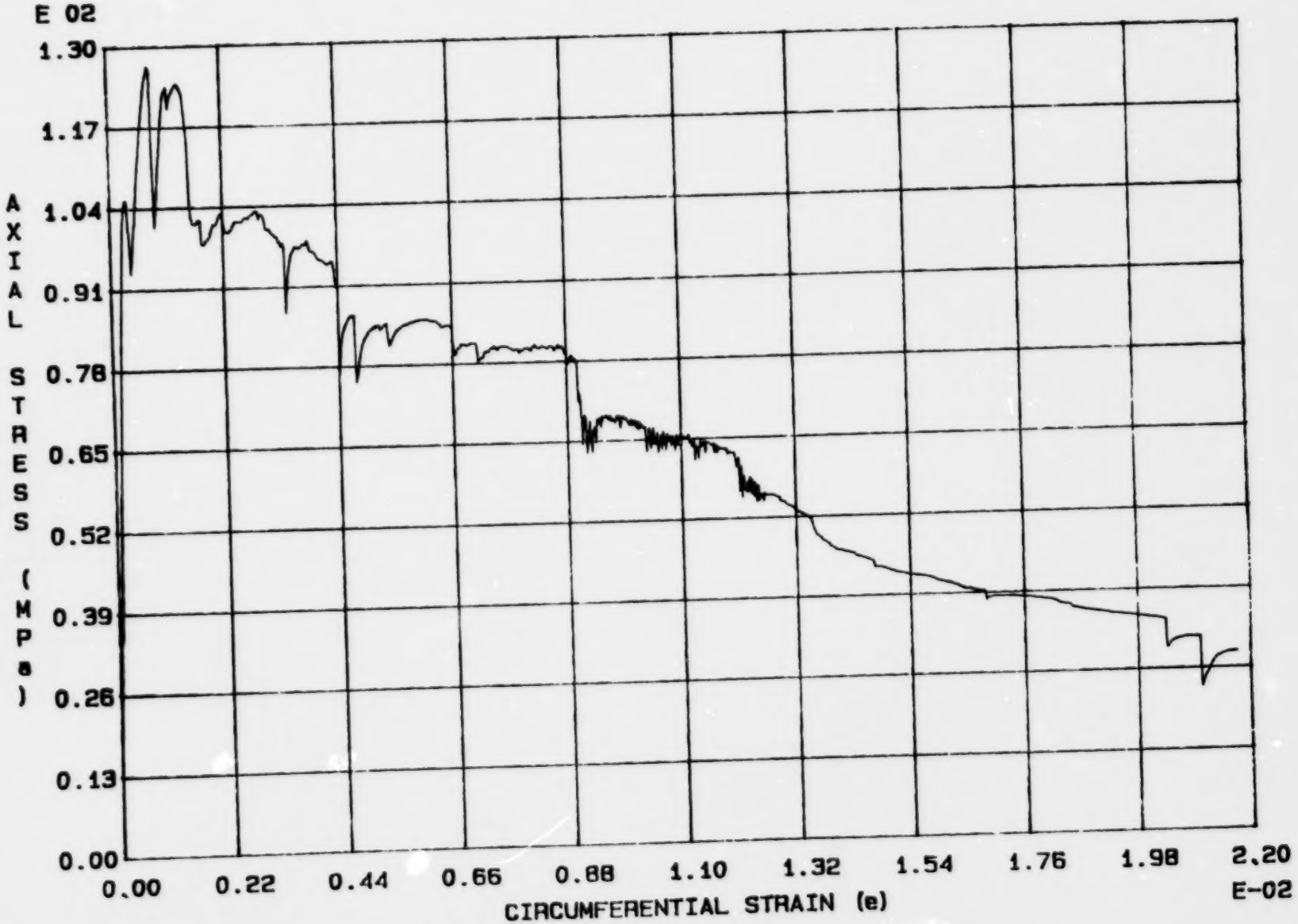

E 02
1.30
1.17
1.04
0.91
0.78
0.65
0.52
0.39
0.26
0.13
0.00
AXIAL STRESS (MPa)
0.00
0.22
0.44
0.66
0.88
1.10
1.32
1.54
1.76
1.98
2.20
E-02
CIRCUMFERENTIAL STRAIN (e)

Fig. B-9 E17U

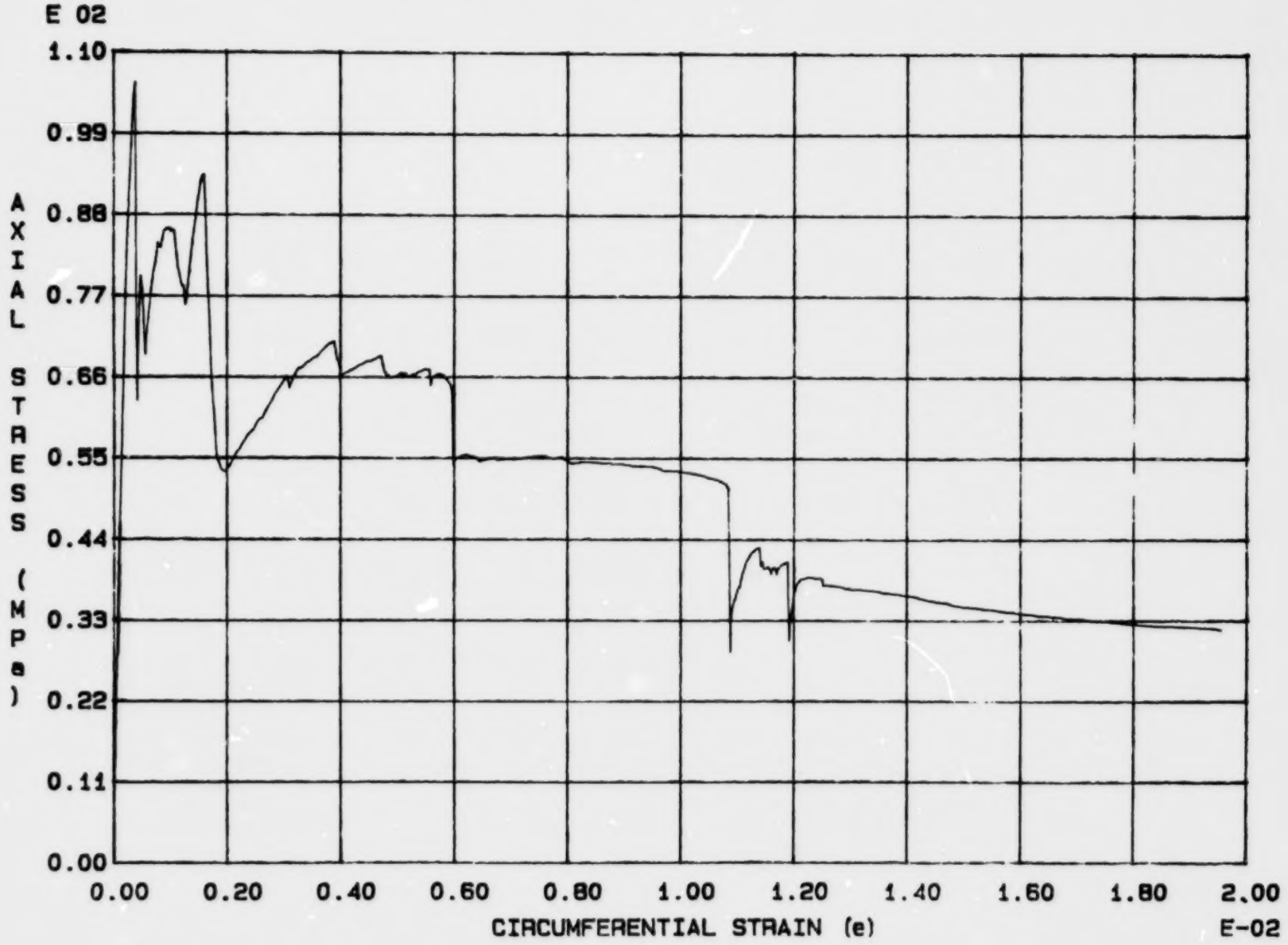

E 02
1.10
0.99
0.88
0.77
0.66
0.55
0.44
0.33
0.22
0.11
0.00
AXIAL STRESS (MPa)
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
1.60
1.80
2.00
CIRCUMFERENTIAL STRAIN (e)
E-02

Fig. B-10 E19U

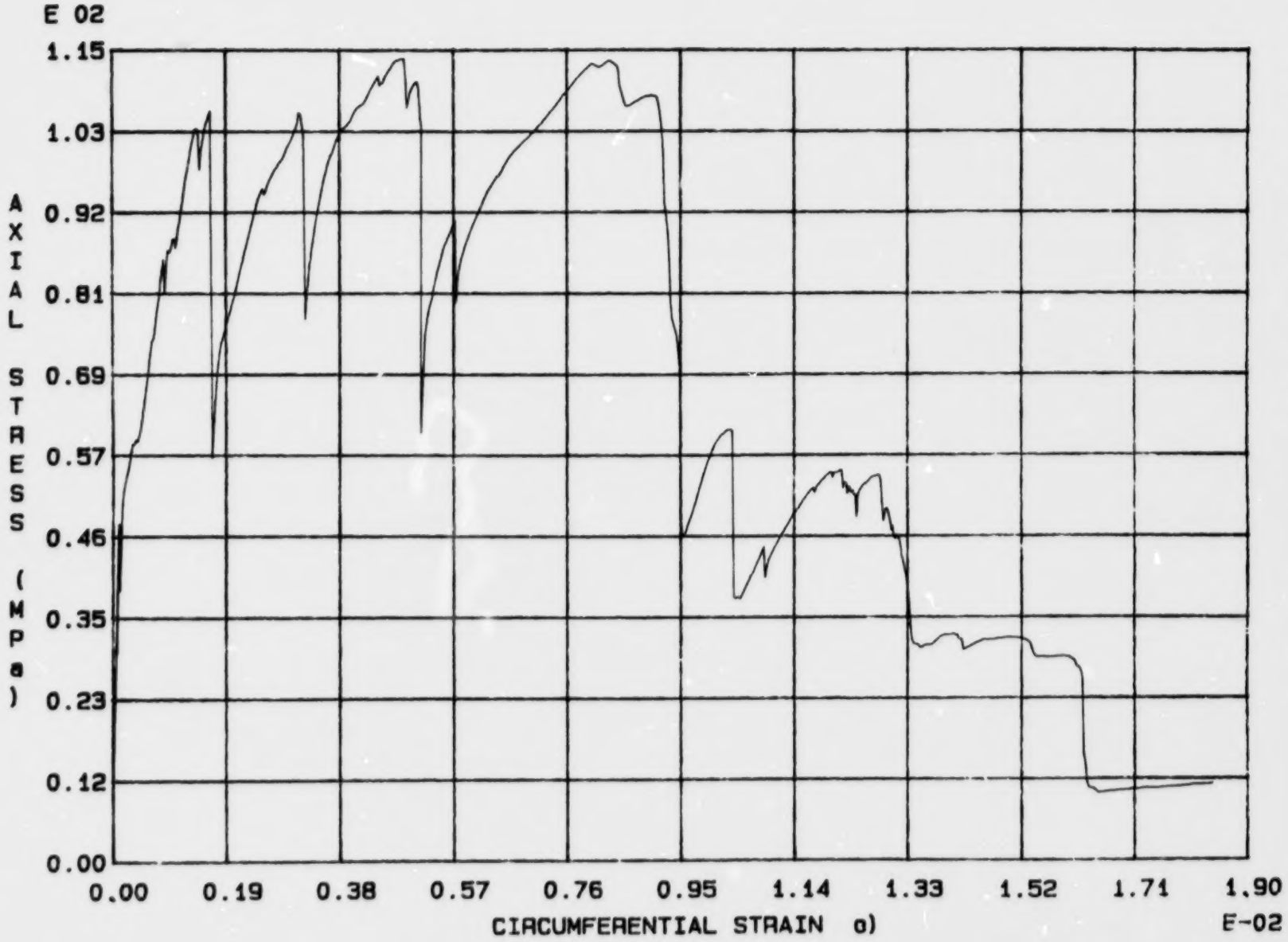

E 02
1.15
1.03
0.92
0.81
0.69
0.57
0.46
0.35
0.23
0.12
0.00
AXIAL STRESS (MPa)
0.00
0.19
0.38
0.57
0.76
0.95
1.14
1.33
1.52
1.71
1.90
CIRCUMFERENTIAL STRAIN a)
E-02

Fig. B-11 E21U

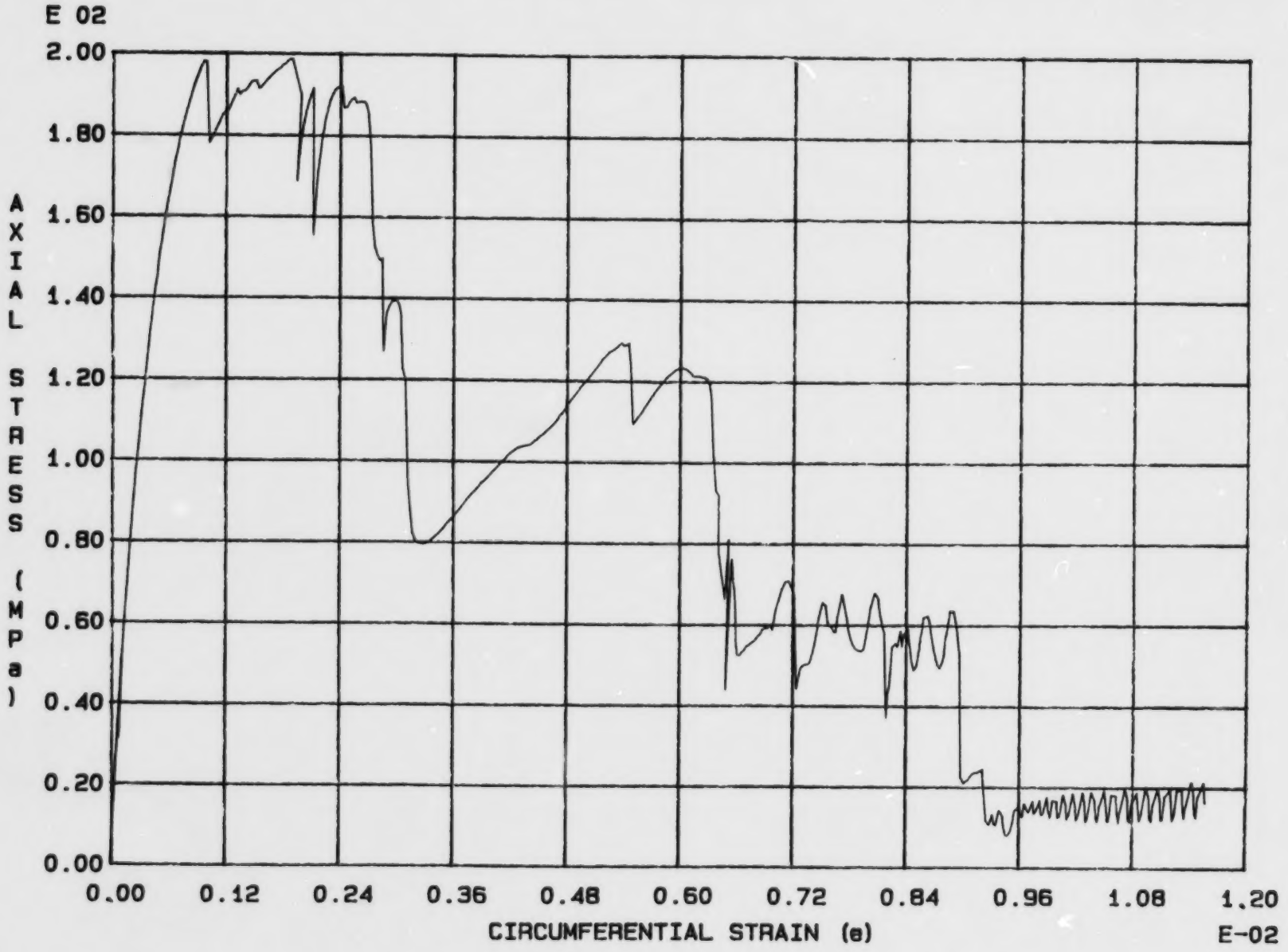

E 02
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
AXIAL STRESS (MPa)
0.00
0.12
0.24
0.36
0.48
0.60
0.72
0.84
0.96
1.08
1.20
CIRCUMFERENTIAL STRAIN (e)
E-02

Fig. B-12 E23U

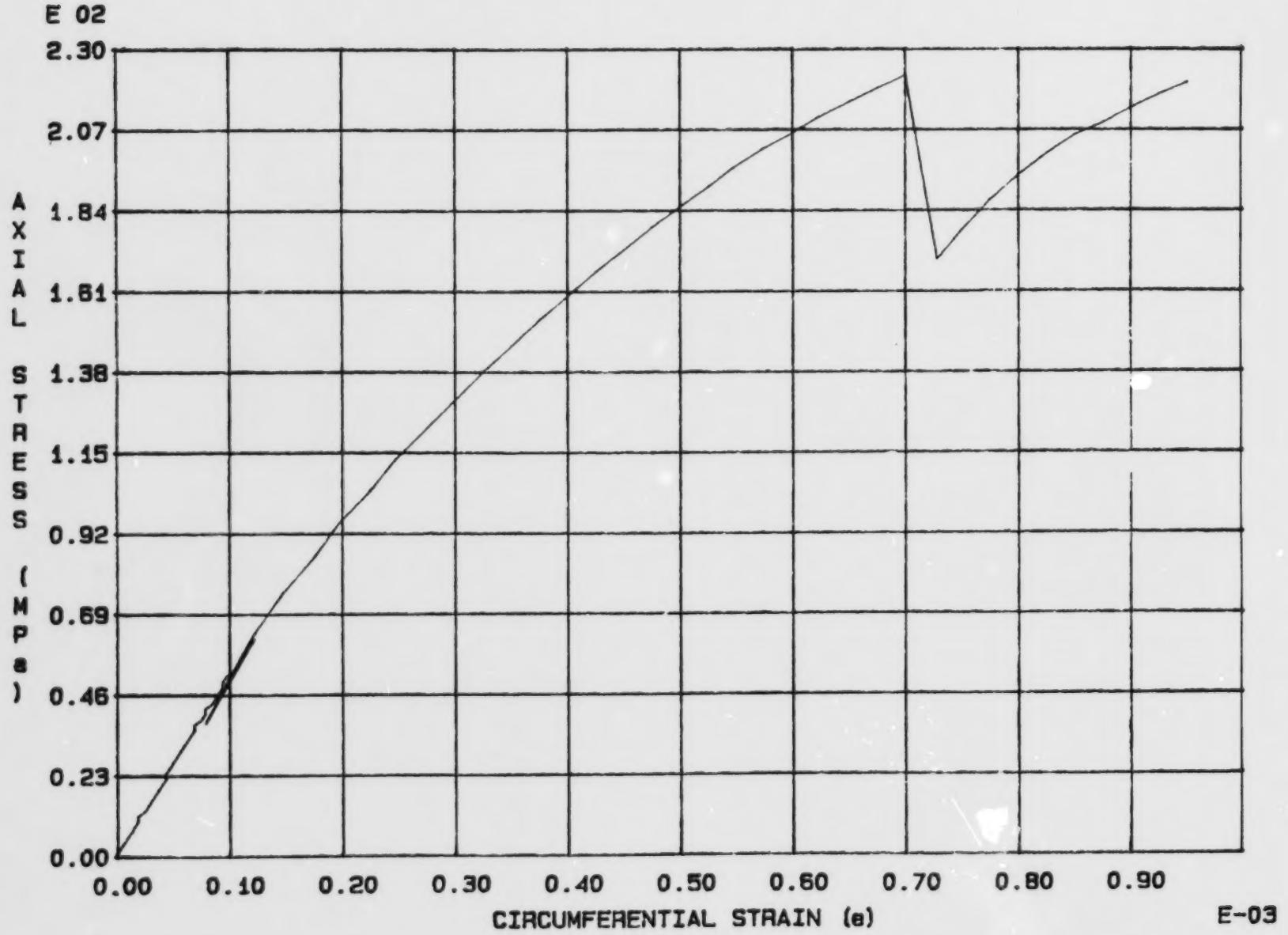

E 02
2.30
2.07
1.84
1.61
1.38
1.15
0.92
0.69
0.46
0.23
0.00
AXIAL STRESS (MPa)
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
CIRCUMFERENTIAL STRAIN (e)
E-03

Fig. B-13 E25U

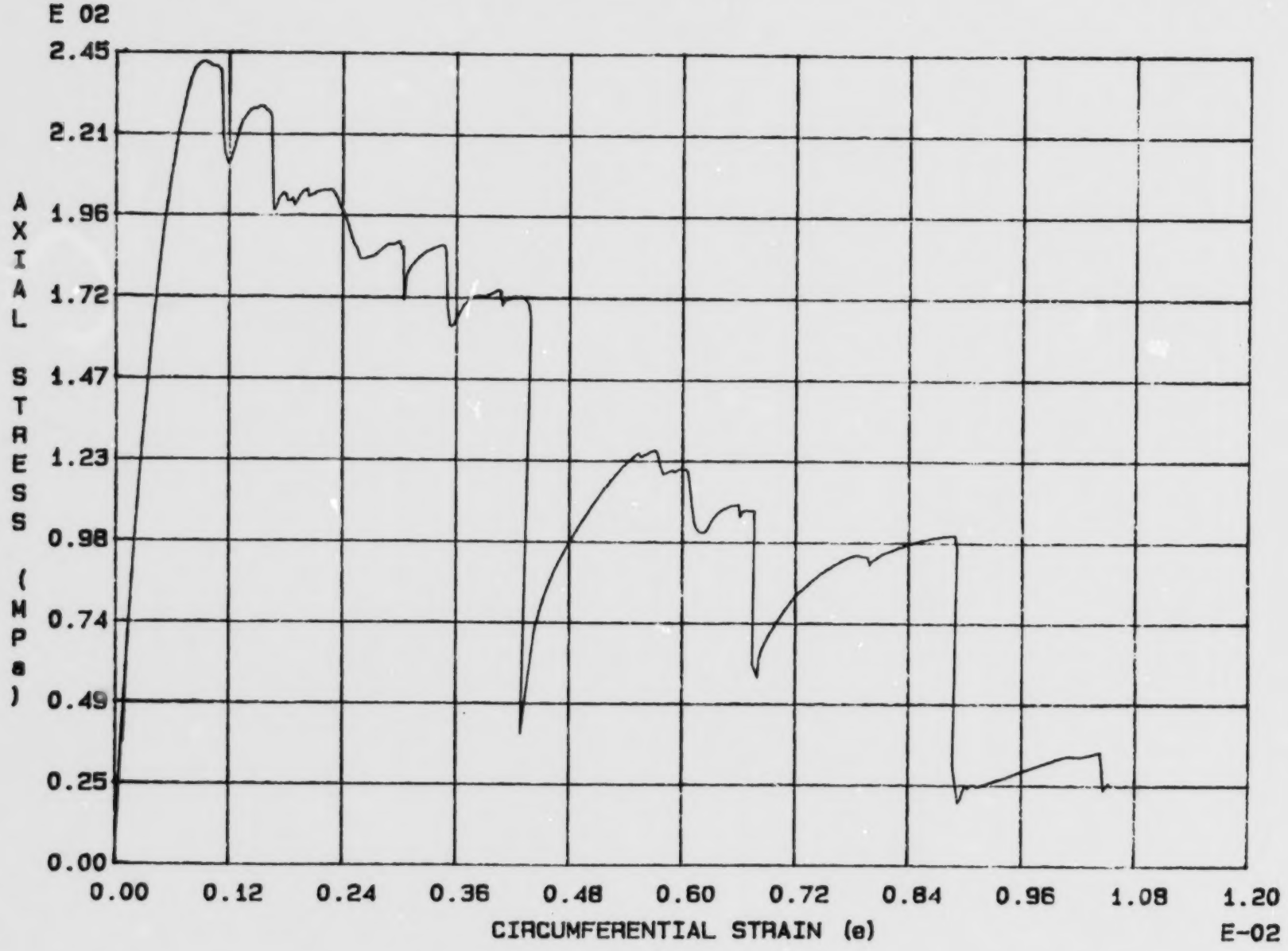

E 02
2.45
2.21
1.96
1.72
1.47
1.23
0.98
0.74
0.49
0.25
0.00
AXIAL STRESS (MPa)
0.00
0.12
0.24
0.36
0.48
0.60
0.72
0.84
0.96
1.08
1.20
CIRCUMFERENTIAL STRAIN (e)
E-02

Fig. B-14 E27U

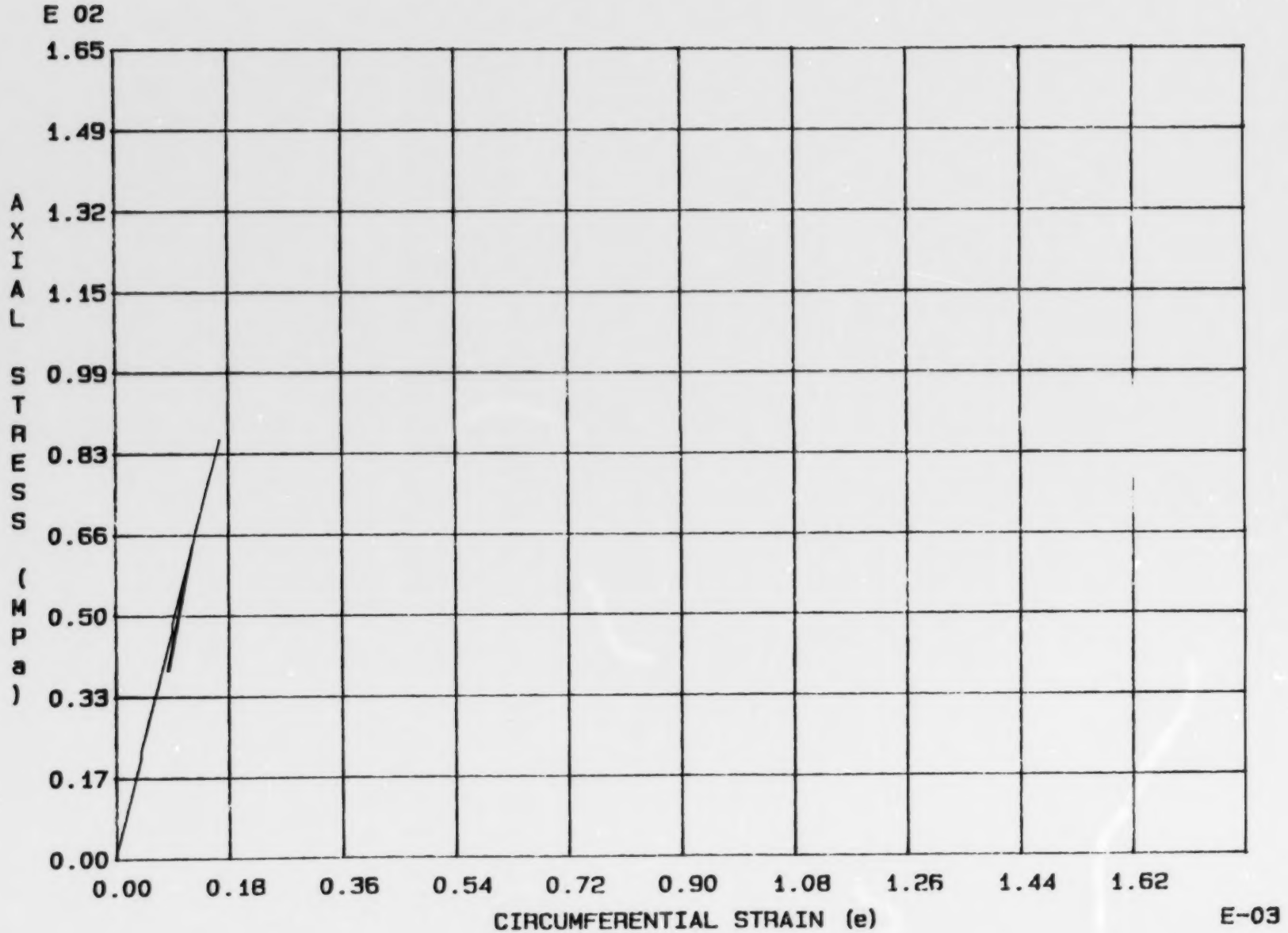

E 02
1.65
1.49
1.32
1.15
0.99
0.83
0.66
0.50
0.33
0.17
0.00
AXIAL STRESS (MPa)
0.00
0.18
0.36
0.54
0.72
0.90
1.08
1.26
1.44
1.62
CIRCUMFERENTIAL STRAIN (e)
E-03

Fig. B-15 E29U

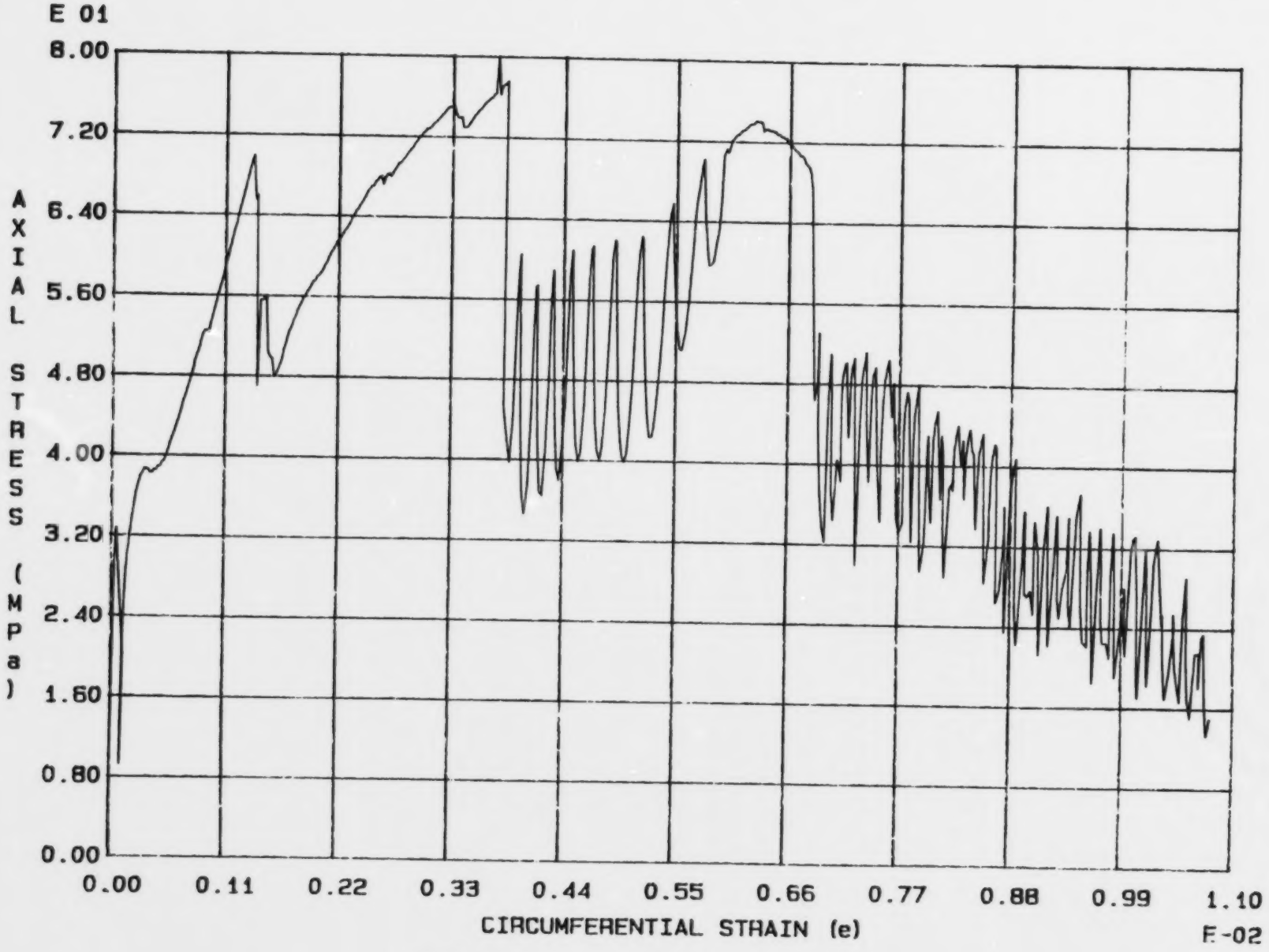

E 01
8.00
7.20
6.40
5.60
4.80
4.00
3.20
2.40
1.60
0.80
0.00
AXIAL STRESS (MPa)
0.00
0.11
0.22
0.33
0.44
0.55
0.66
0.77
0.88
0.99
1.10
CIRCUMFERENTIAL STRAIN (e)
E-02

Fig. B-16 E31U

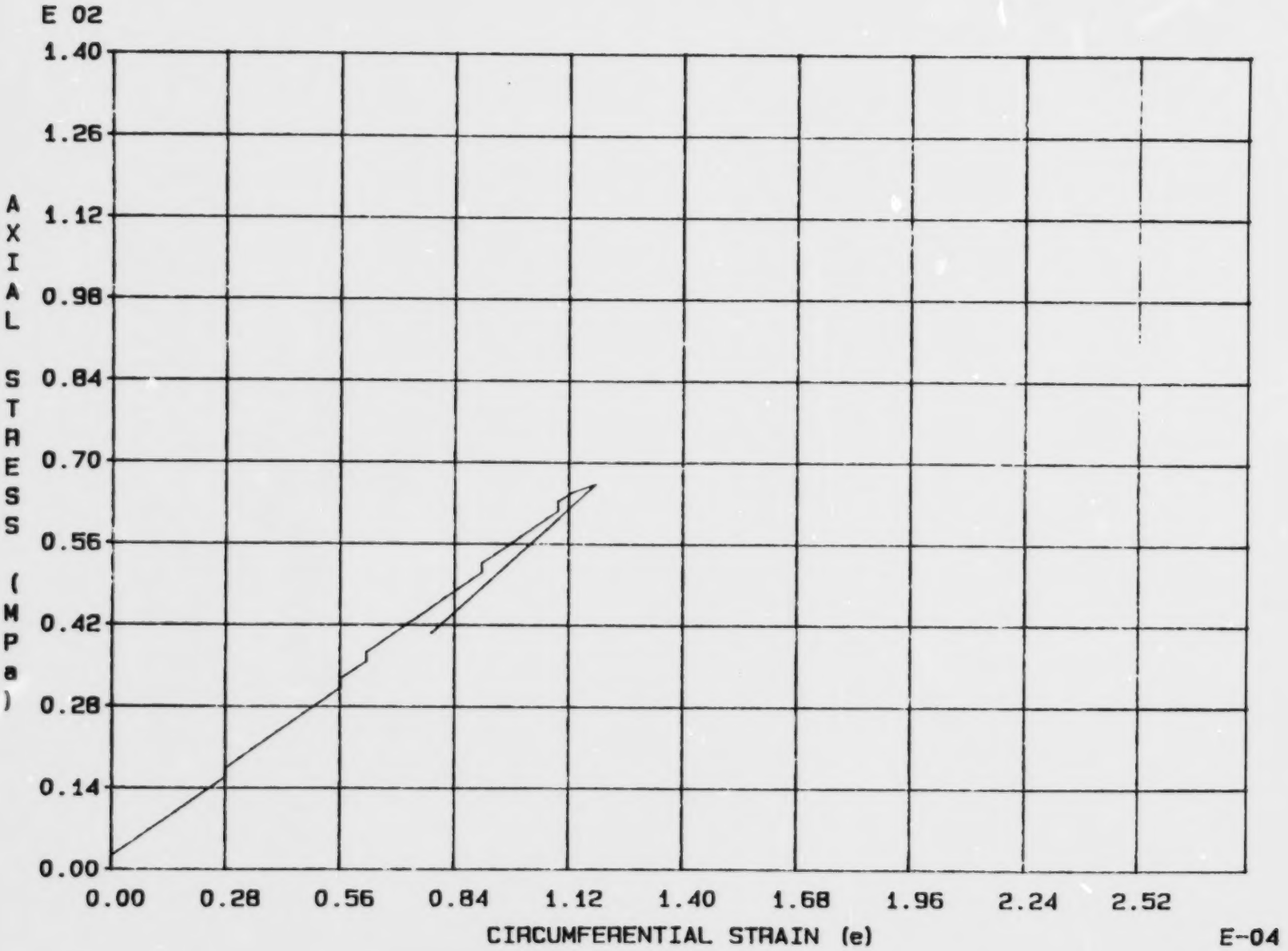

E 02
1.40
1.26
1.12
0.98
0.84
0.70
0.56
0.42
0.28
0.14
0.00
AXIAL STRESS (MPa)
0.00
0.28
0.56
0.84
1.12
1.40
1.68
1.96
2.24
2.52
CIRCUMFERENTIAL STRAIN (e)
E-04

Fig. B-17 E33U

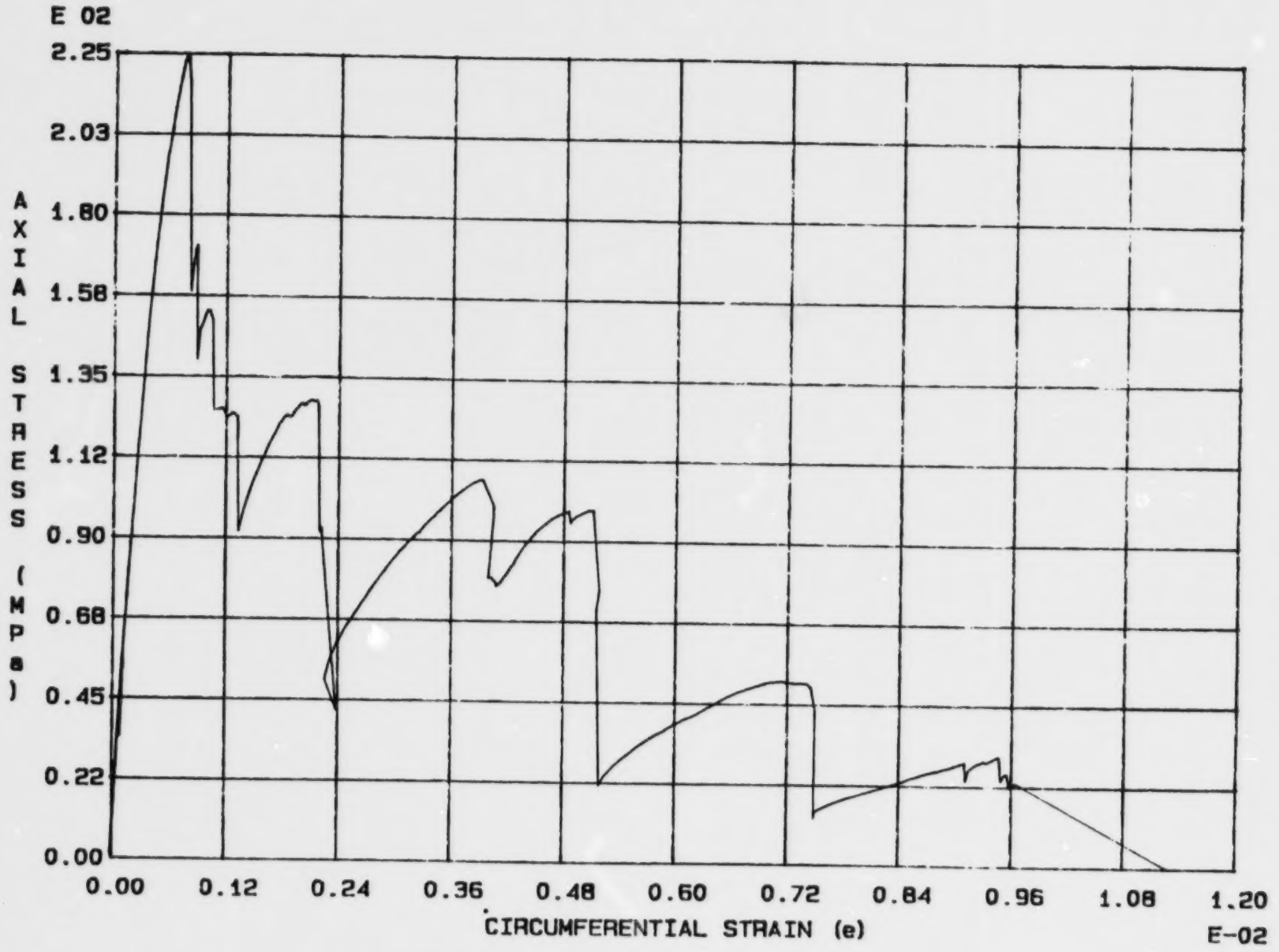

E 02
2.25
2.03
1.80
1.58
1.35
1.12
0.90
0.68
0.45
0.22
0.00
AXIAL STRESS (MPa)
0.00
0.12
0.24
0.36
0.48
0.60
0.72
0.84
0.96
1.08
1.20
CIRCUMFERENTIAL STRAIN (e)
E-02

Fig. B-18 E35U

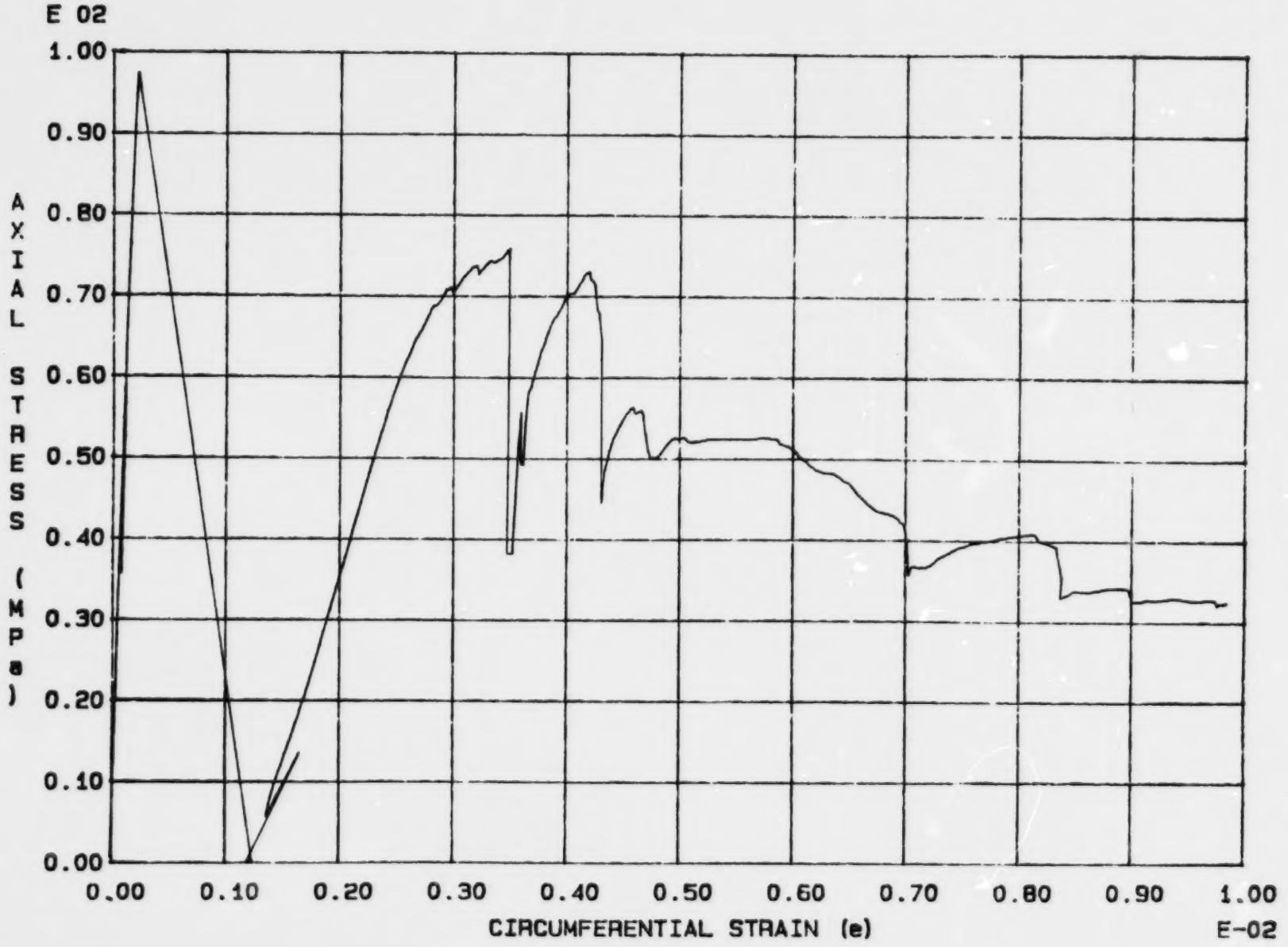

E 02
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
AXIAL STRESS (MPa)
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
CIRCUMFERENTIAL STRAIN (e)
E-02

Fig. B-19 E37U

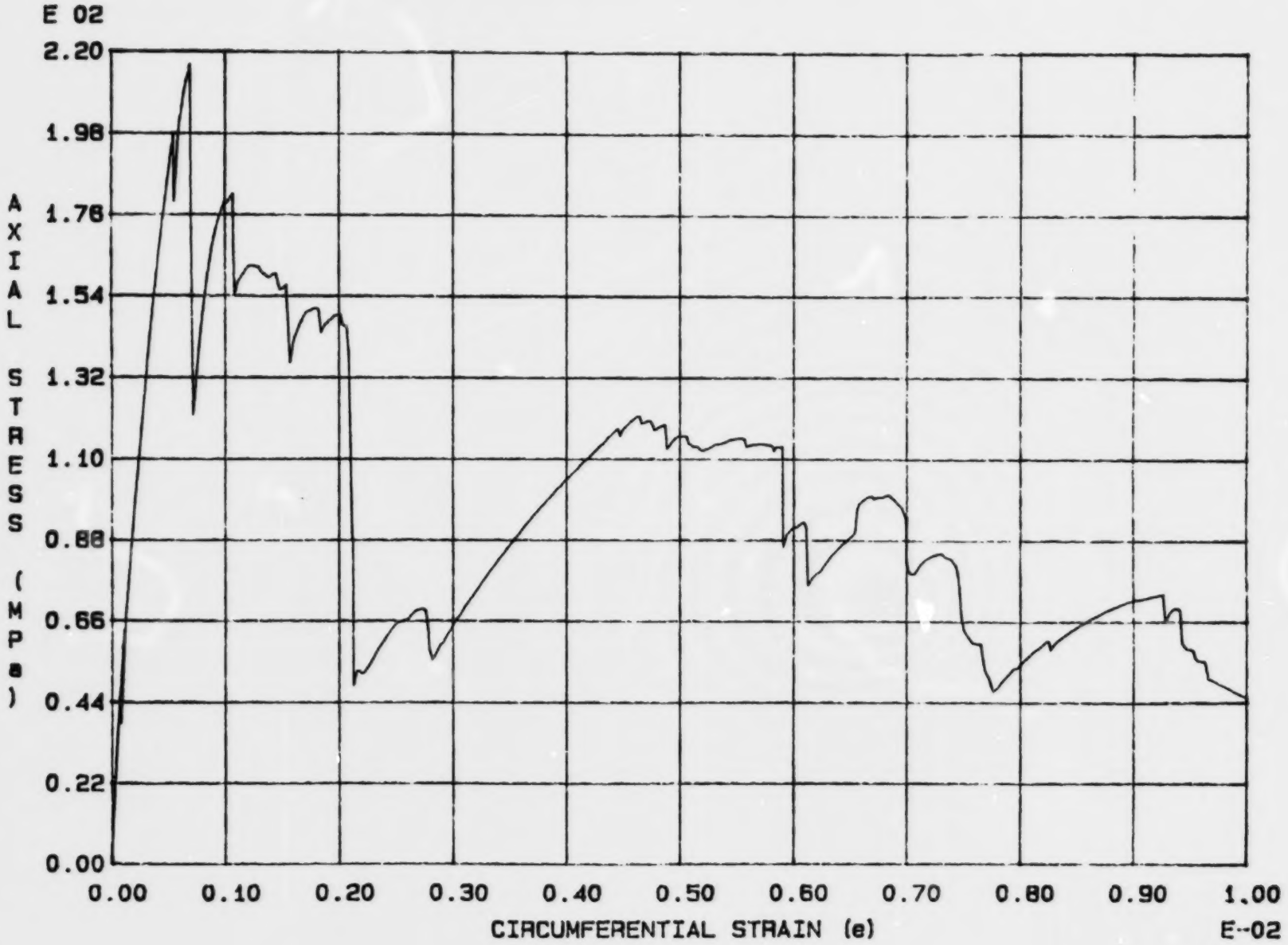

E 02
2.20
1.98
1.76
1.54
1.32
1.10
0.88
0.66
0.44
0.22
0.00
AXIAL STRESS (MPa)
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
CIRCUMFERENTIAL STRAIN (e)
E-02

Fig. B-20 E39U

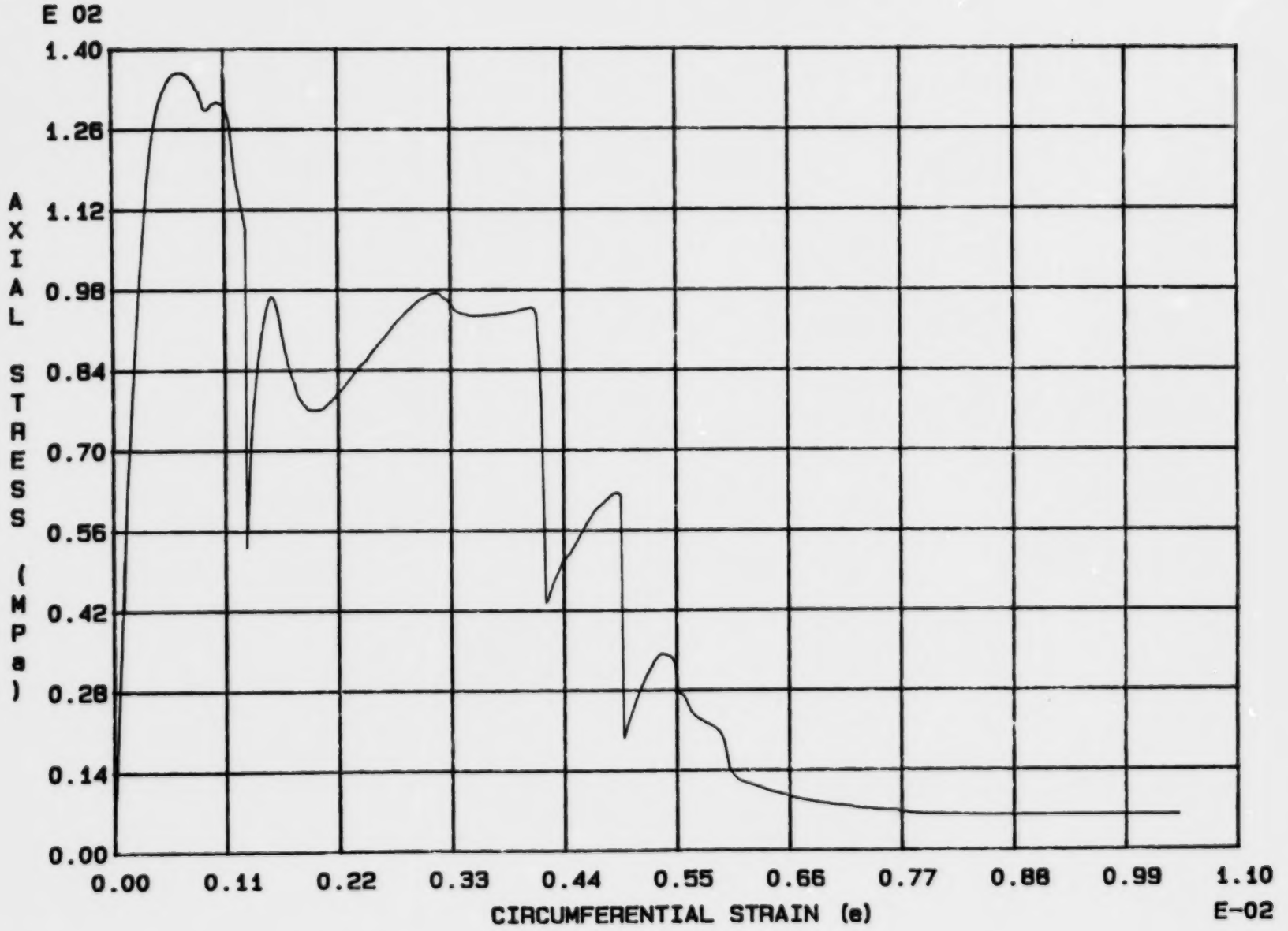

E 02
1.40
1.26
1.12
0.98
0.84
0.70
0.56
0.42
0.28
0.14
0.00
AXIAL STRESS (MPa)
0.00
0.11
0.22
0.33
0.44
0.55
0.66
0.77
0.88
0.99
1.10
CIRCUMFERENTIAL STRAIN (e)
E-02

Fig. B-21 E41U

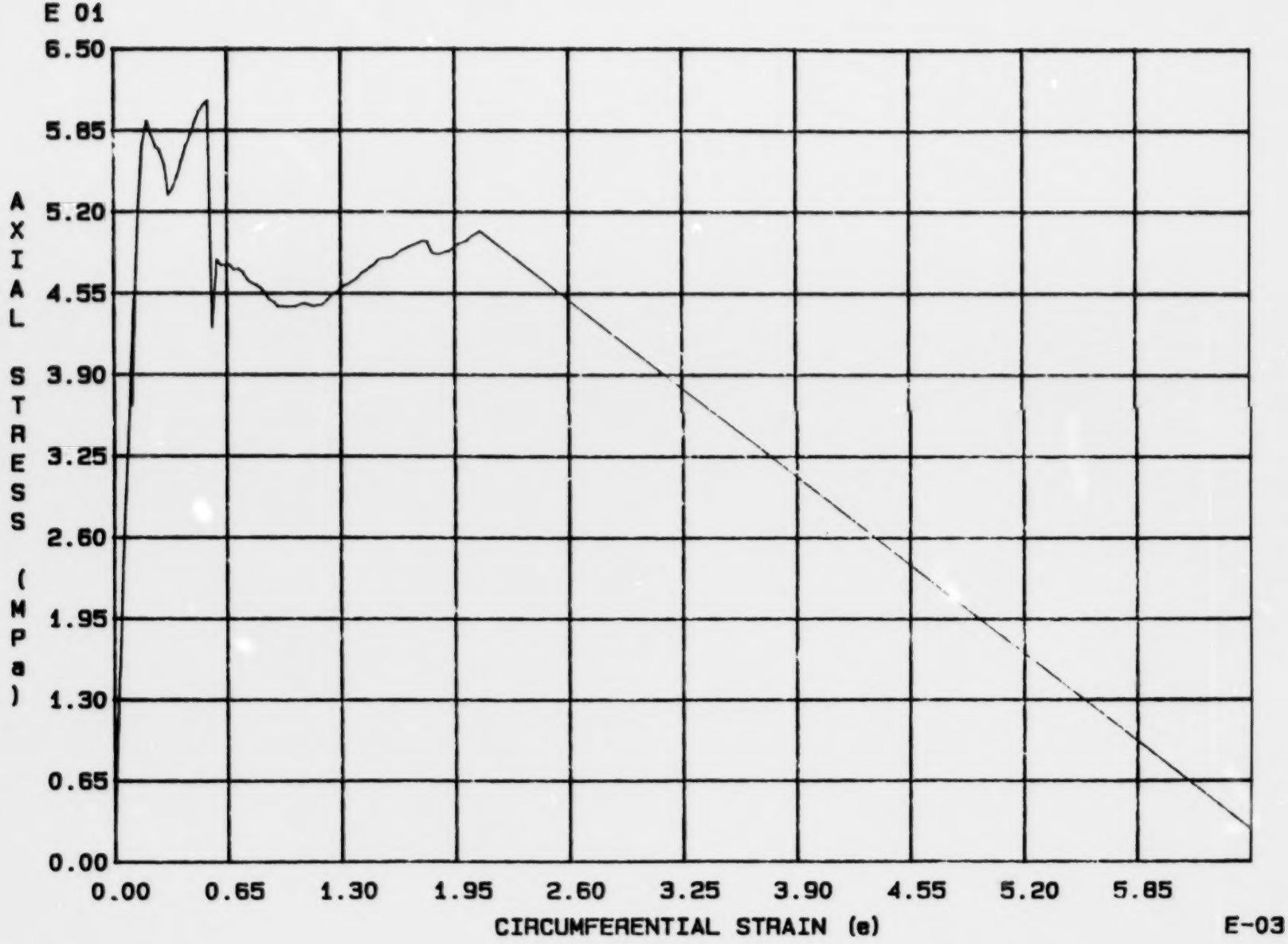

E 01
6.50
5.85
5.20
4.55
3.90
3.25
2.60
1.95
1.30
0.65
0.00
AXIAL STRESS (MPa)
0.00
0.65
1.30
1.95
2.60
3.25
3.90
4.55
5.20
5.85
CIRCUMFERENTIAL STRAIN (e)
E-03

Fig. B-22 E43U

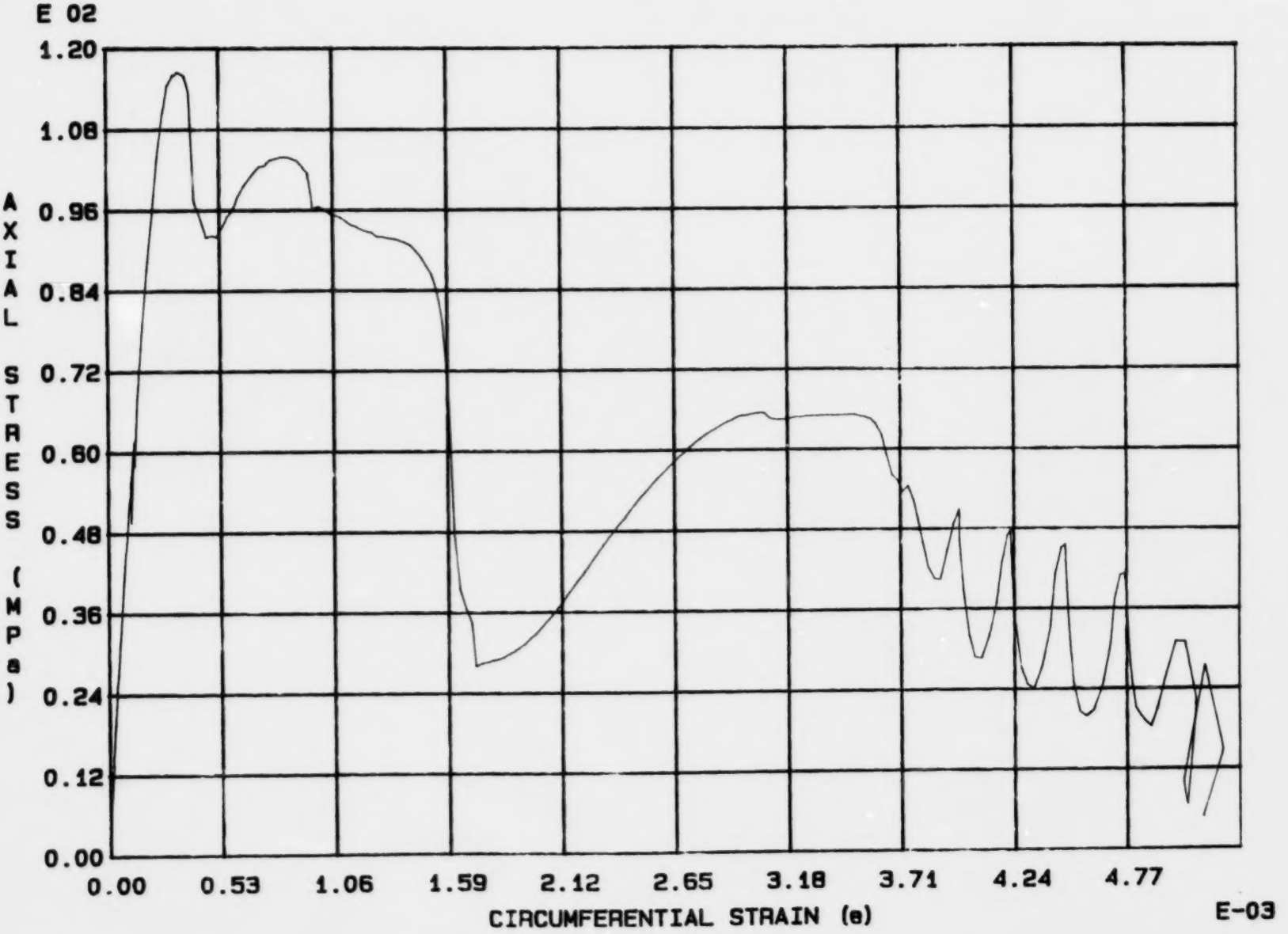

E 02
1.20
1.08
0.96
0.84
0.72
0.60
0.48
0.36
0.24
0.12
0.00
AXIAL STRESS (MPa)
0.00
0.53
1.06
1.59
2.12
2.65
3.18
3.71
4.24
4.77
CIRCUMFERENTIAL STRAIN (e)
E-03

Fig. B-23 E45U

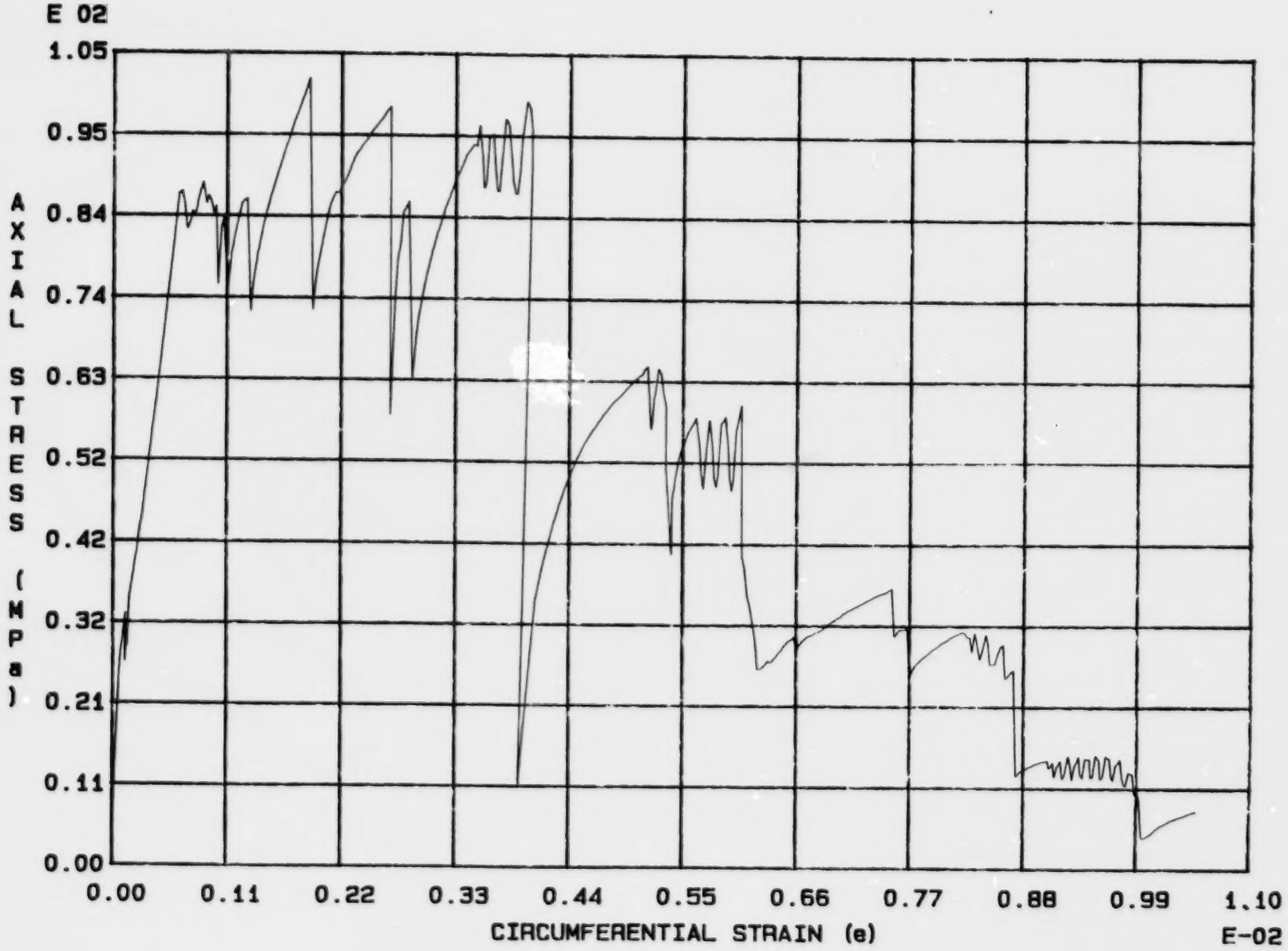

E 02
1.05
0.95
0.84
0.74
0.63
0.52
0.42
0.32
0.21
0.11
0.00
AXIAL STRESS (MPa)
0.00
0.11
0.22
0.33
0.44
0.55
0.66
0.77
0.88
0.99
1.10
CIRCUMFERENTIAL STRAIN (e)
E-02

Fig. B-24 E47U

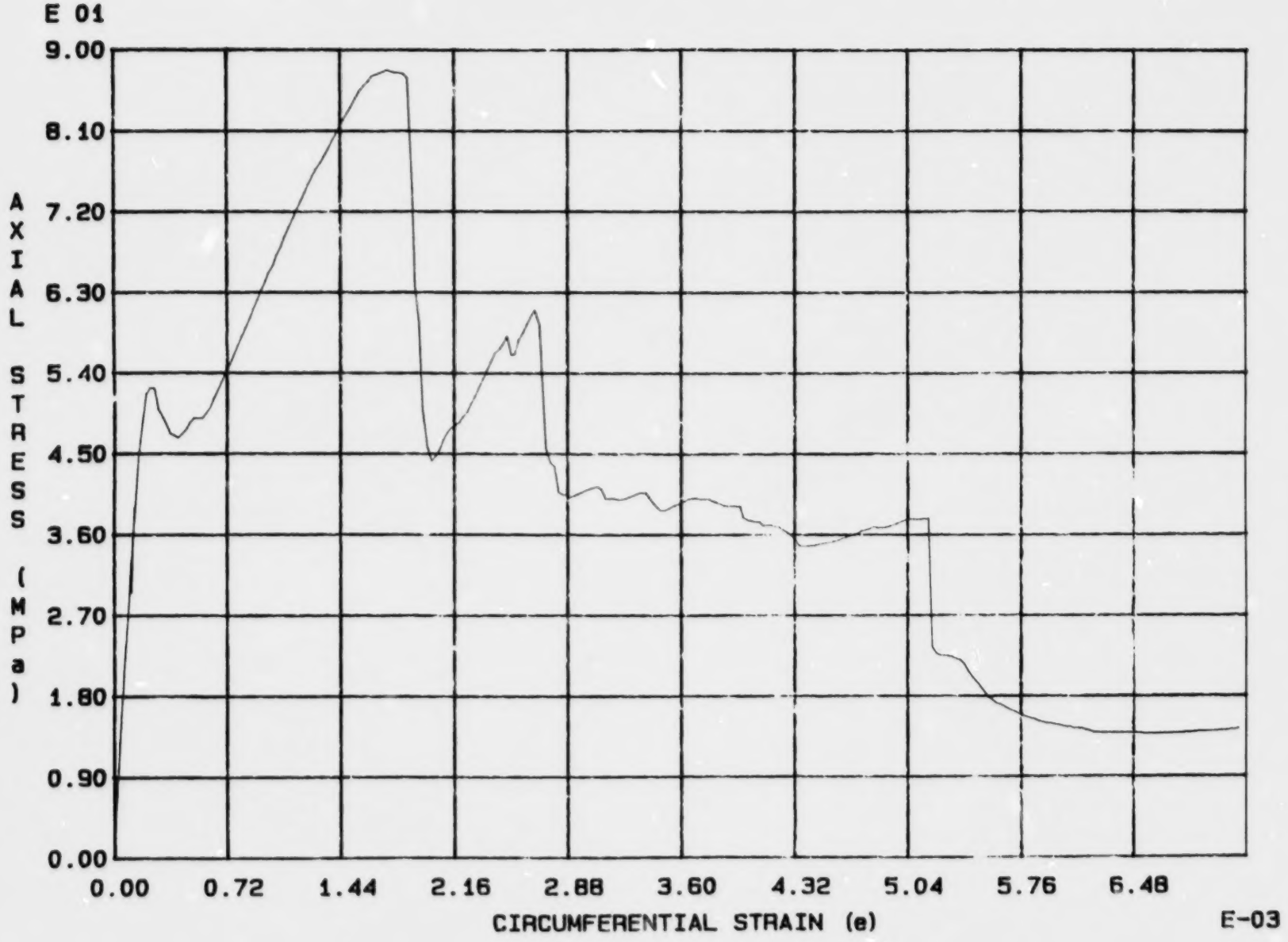

E 01
9.00
8.10
7.20
6.30
5.40
4.50
3.60
2.70
1.80
0.90
0.00
AXIAL STRESS (MPa)
0.00
0.72
1.44
2.16
2.88
3.60
4.32
5.04
5.76
6.48
CIRCUMFERENTIAL STRAIN (e)
E-03

Fig. B-25 E49U

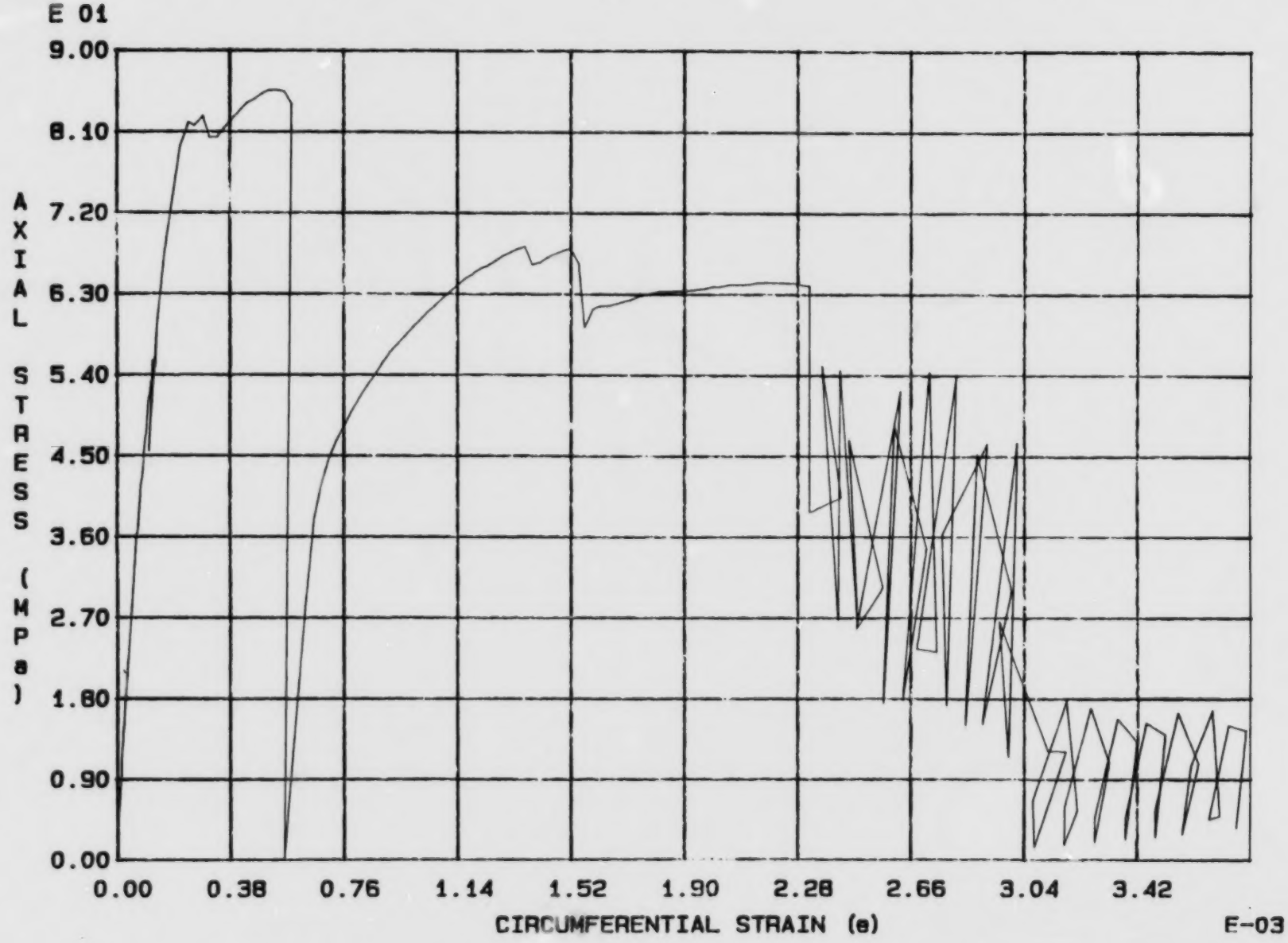

E 01
9.00
8.10
7.20
6.30
5.40
4.50
3.60
2.70
1.80
0.90
0.00
AXIAL STRESS (MPa)
0.00
0.38
0.76
1.14
1.52
1.90
2.28
2.66
3.04
3.42
CIRCUMFERENTIAL STRAIN (e)
E-03

Fig. B-26 E51U

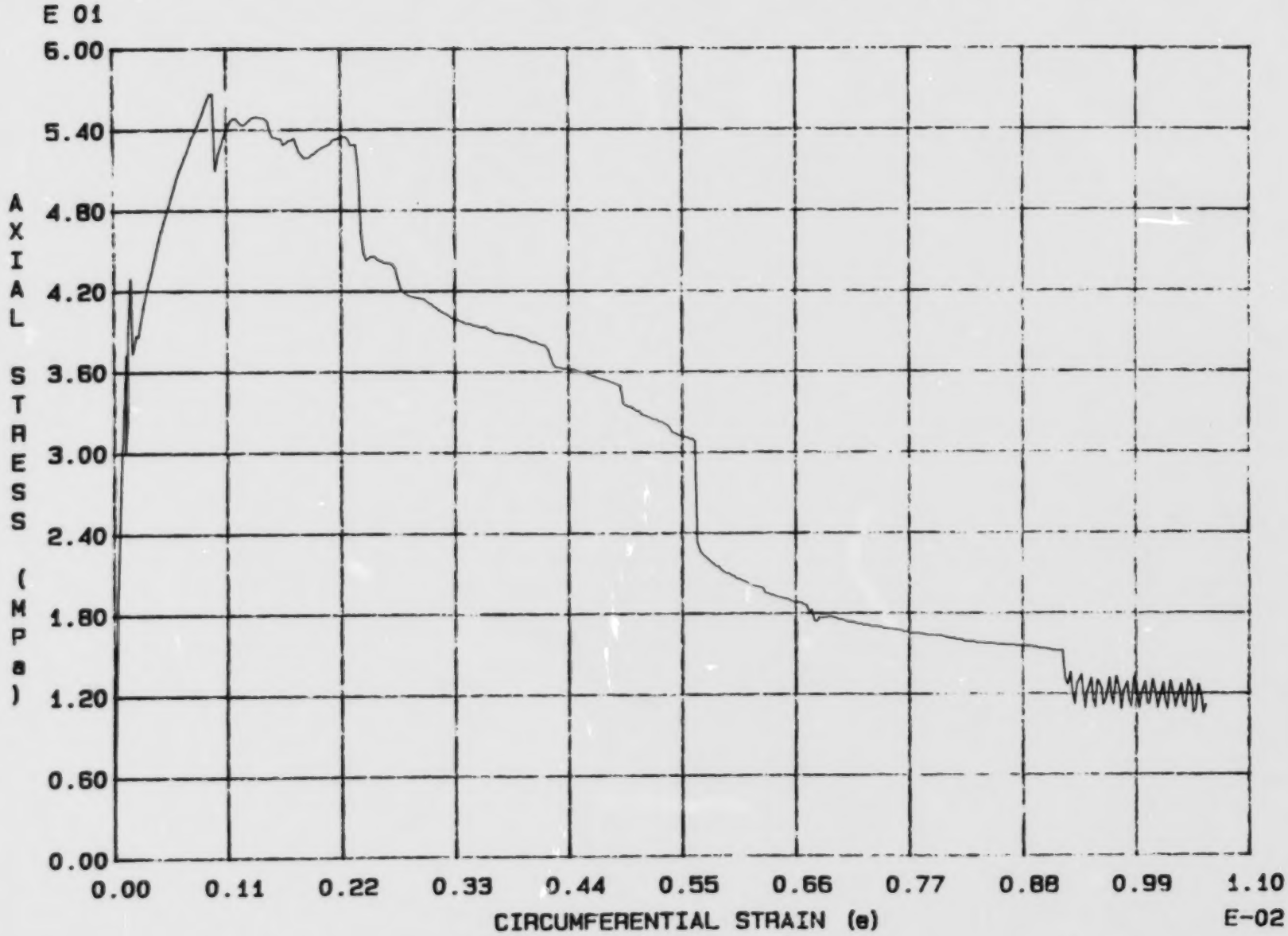

E 01
6.00
5.40
4.80
4.20
3.60
3.00
2.40
1.80
1.20
0.60
0.00
AXIAL STRESS (MPa)
0.00
0.11
0.22
0.33
0.44
0.55
0.66
0.77
0.88
0.99
1.10
CIRCUMFERENTIAL STRAIN (e)
E-02

Fig. B-27 E53U

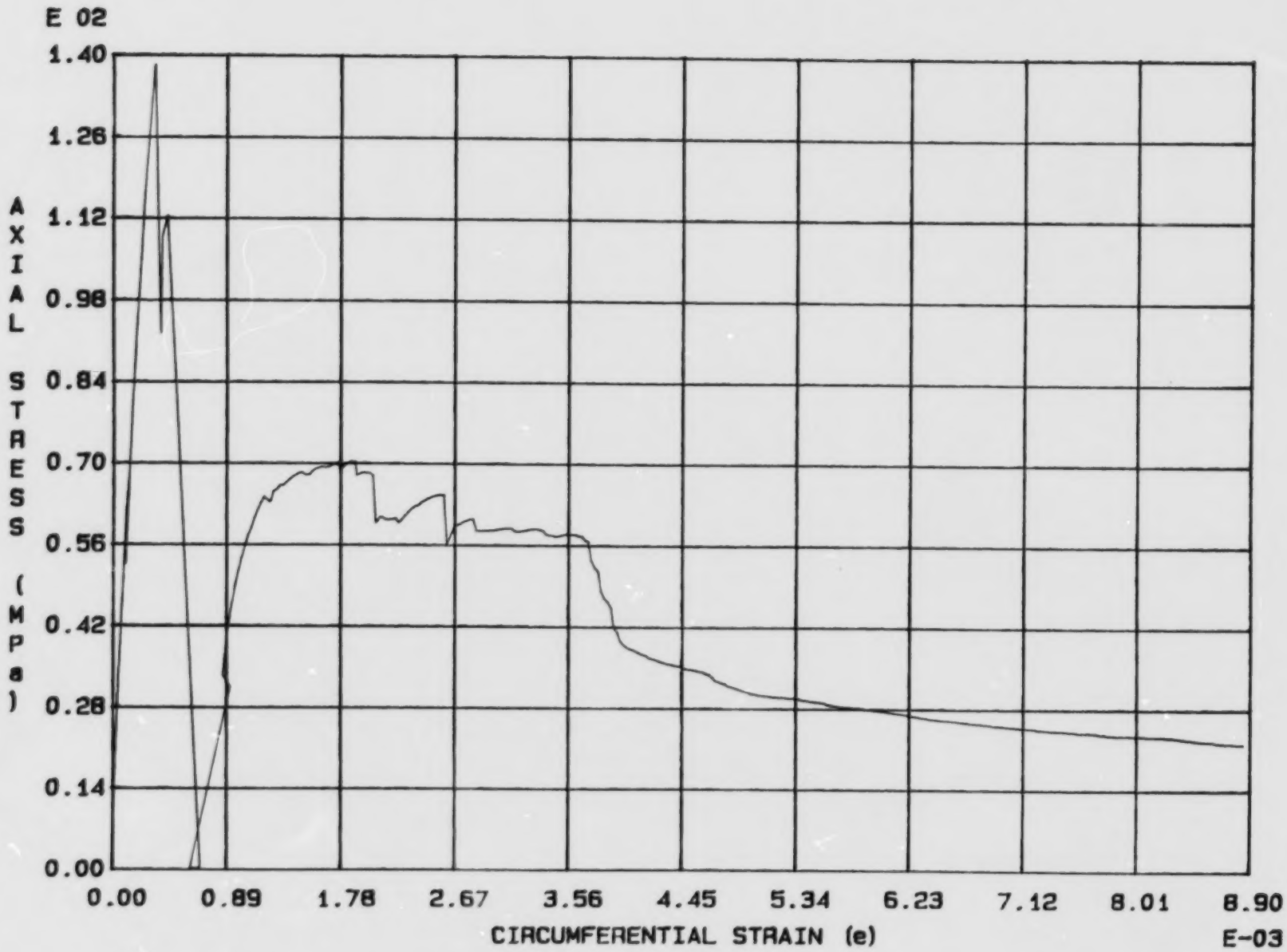

E 02
1.40
1.26
1.12
0.98
0.84
0.70
0.56
0.42
0.28
0.14
0.00
AXIAL STRESS (MPa)
0.00
0.89
1.78
2.67
3.56
4.45
5.34
6.23
7.12
8.01
8.90
CIRCUMFERENTIAL STRAIN (e)
E-03

Fig. B-28 E55U

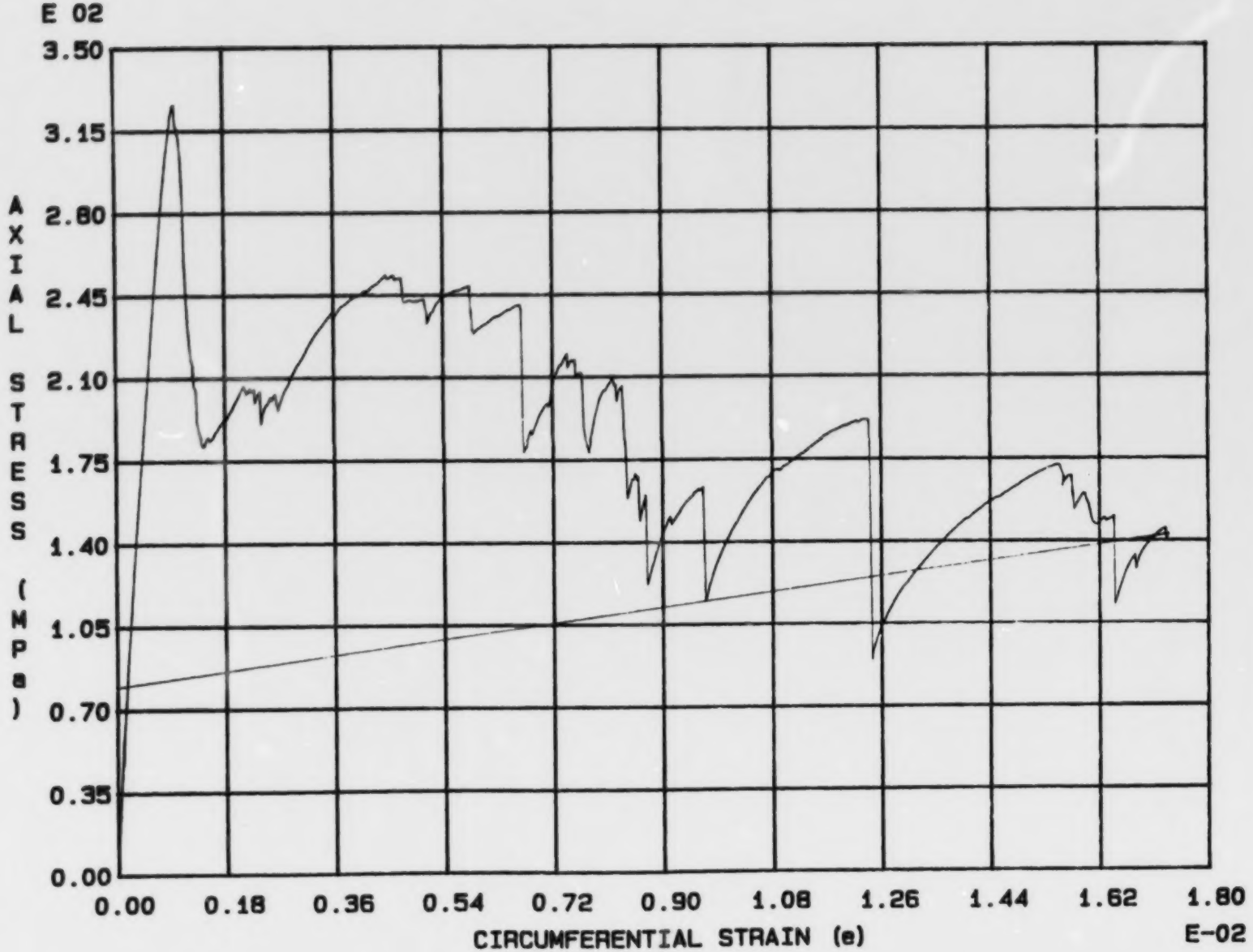

E 02
3.50
3.15
2.80
2.45
2.10
1.75
1.40
1.05
0.70
0.35
0.00
AXIAL STRESS (MPa)
0.00
0.18
0.36
0.54
0.72
0.90
1.08
1.26
1.44
1.62
1.80
CIRCUMFERENTIAL STRAIN (e)
E-02

Fig. B-29 E57U

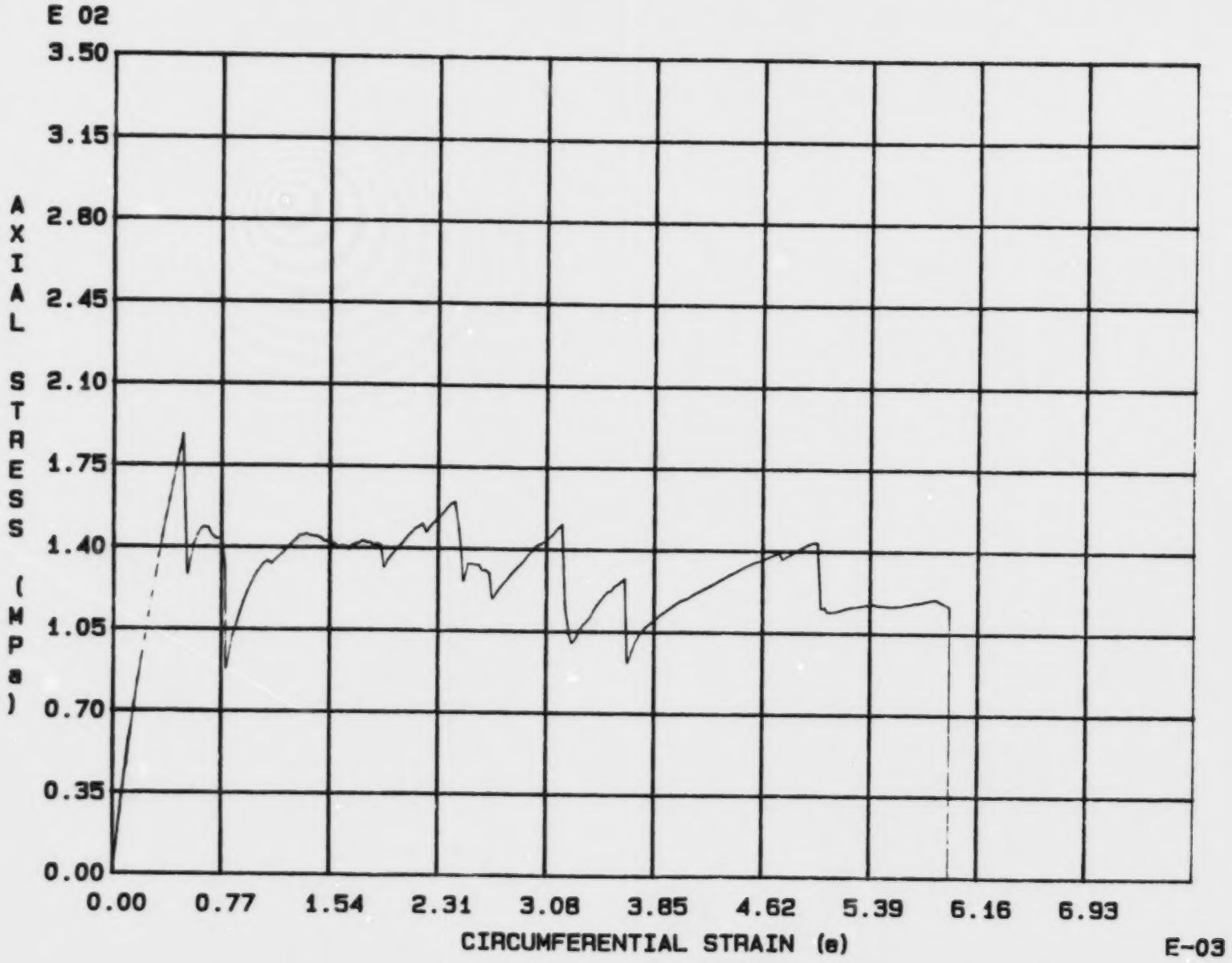

E 02
3.50
3.15
2.80
2.45
2.10
1.75
1.40
1.05
0.70
0.35
0.00
AXIAL STRESS (MPa)
0.00
0.77
1.54
2.31
3.08
3.85
4.62
5.39
6.16
6.93
CIRCUMFERENTIAL STRAIN (e)
E-03

Fig. B-30 E58U

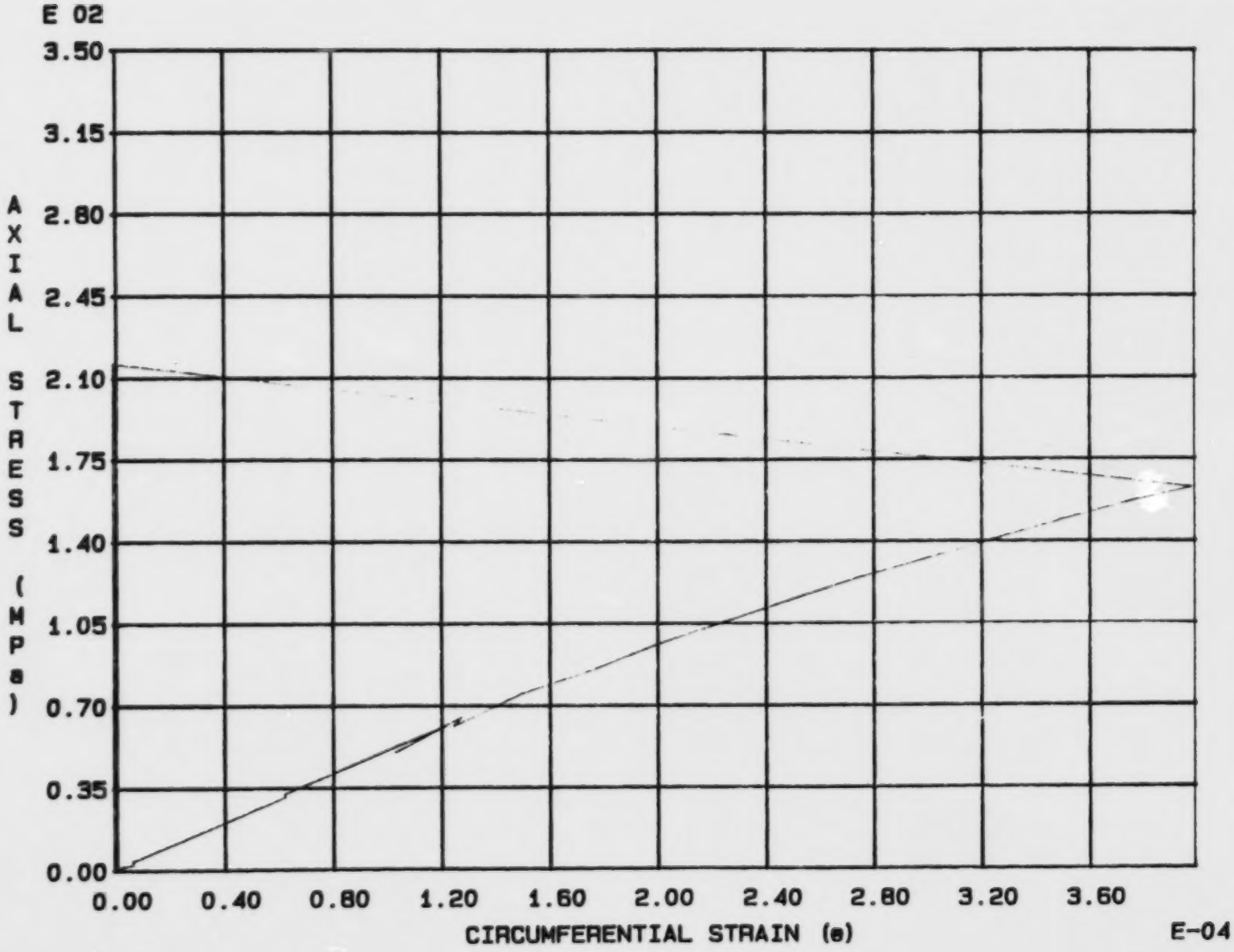

E 02
3.50
3.15
2.80
2.45
2.10
1.75
1.40
1.05
0.70
0.35
0.00
AXIAL STRESS (MPa)
0.00
0.40
0.80
1.20
1.60
2.00
2.40
2.80
3.20
3.60
CIRCUMFERENTIAL STRAIN (e)
E-04

Fig. B-31 E59U

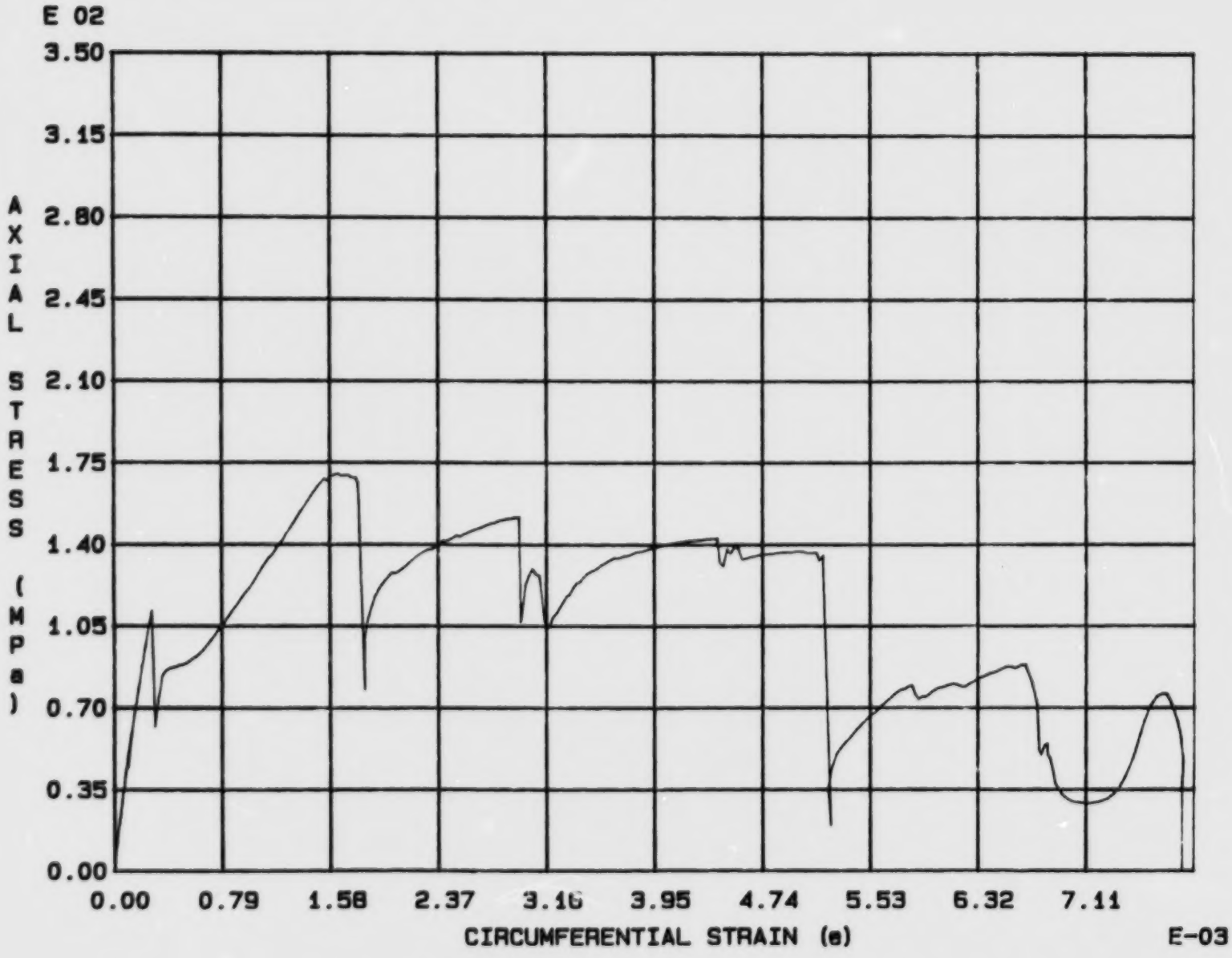

E 02
3.50
3.15
2.80
2.45
2.10
1.75
1.40
1.05
0.70
0.35
0.00
AXIAL STRESS (MPa)
0.00
0.79
1.58
2.37
3.16
3.95
4.74
5.53
6.32
7.11
CIRCUMFERENTIAL STRAIN (e)
E-03

Fig. B-32 E60U

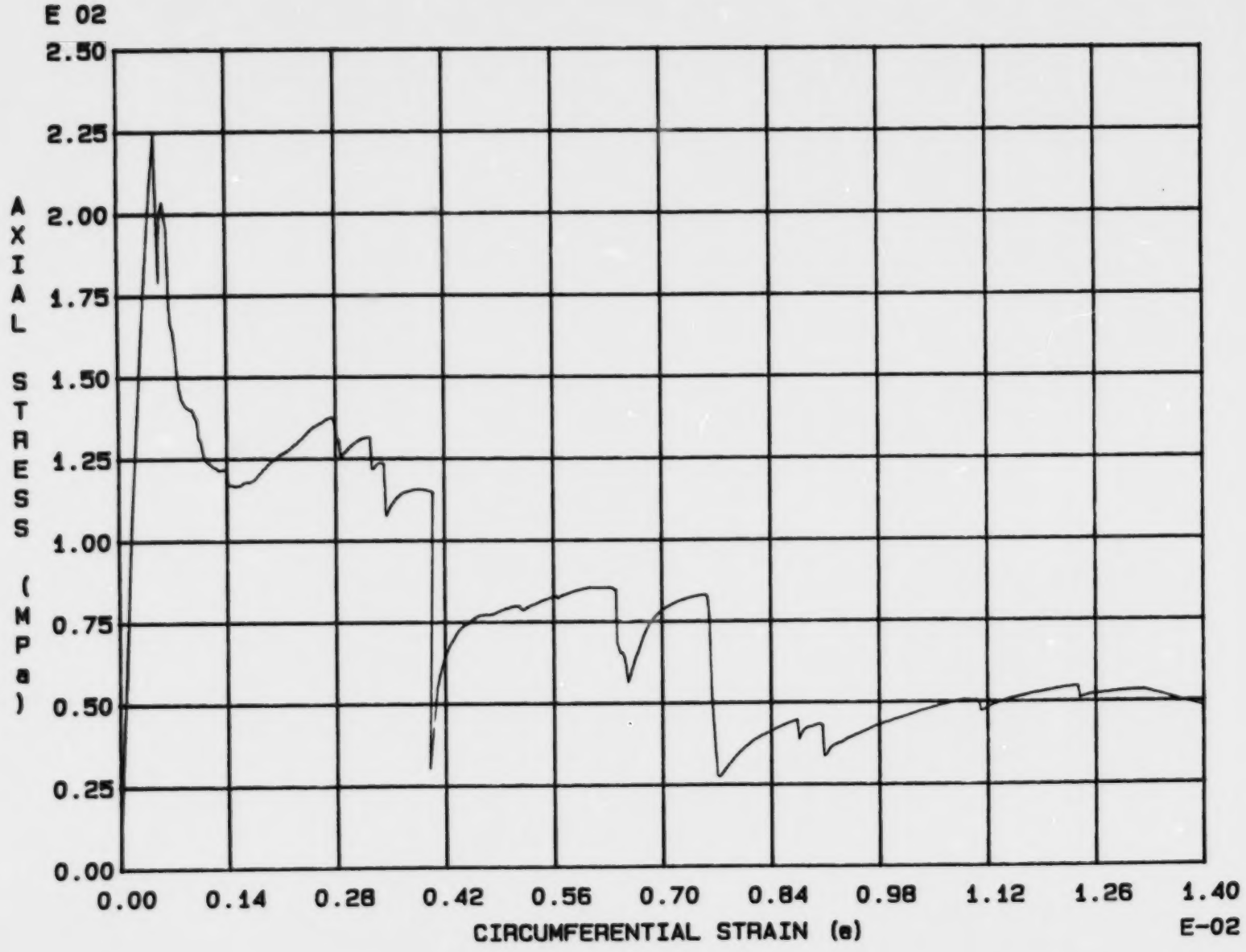

E 02
2.50
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
AXIAL STRESS (MPa)
0.00
0.14
0.28
0.42
0.56
0.70
0.84
0.98
1.12
1.26
1.40
E-02
CIRCUMFERENTIAL STRAIN (e)

Fig. B-33 E72U

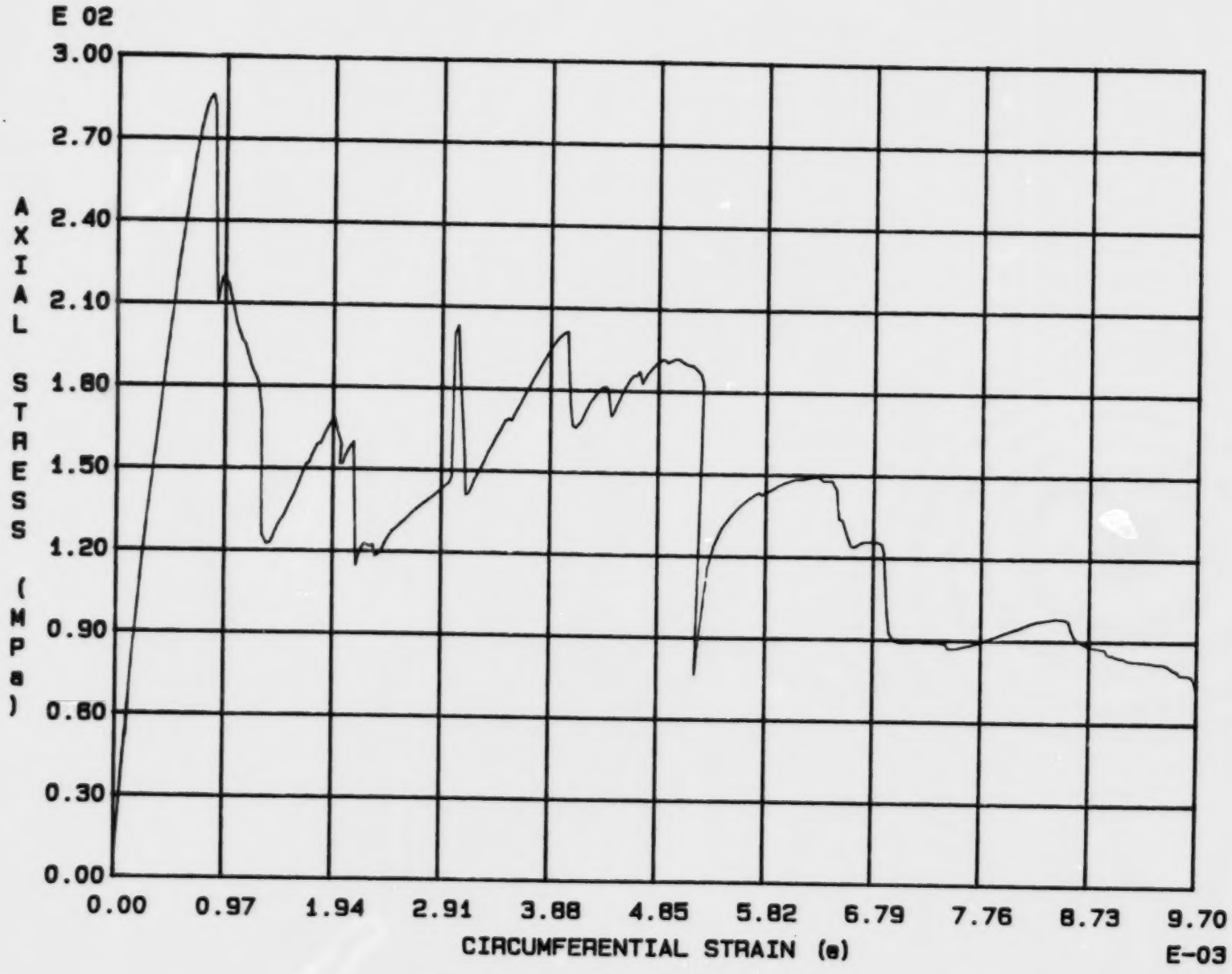

E 02
3.00
2.70
2.40
2.10
1.80
1.50
1.20
0.90
0.60
0.30
0.00
AXIAL STRESS (MPa)
0.00
0.97
1.94
2.91
3.88
4.85
5.82
6.79
7.76
8.73
9.70
CIRCUMFERENTIAL STRAIN (e)
E-03

Fig. B-34 E73U

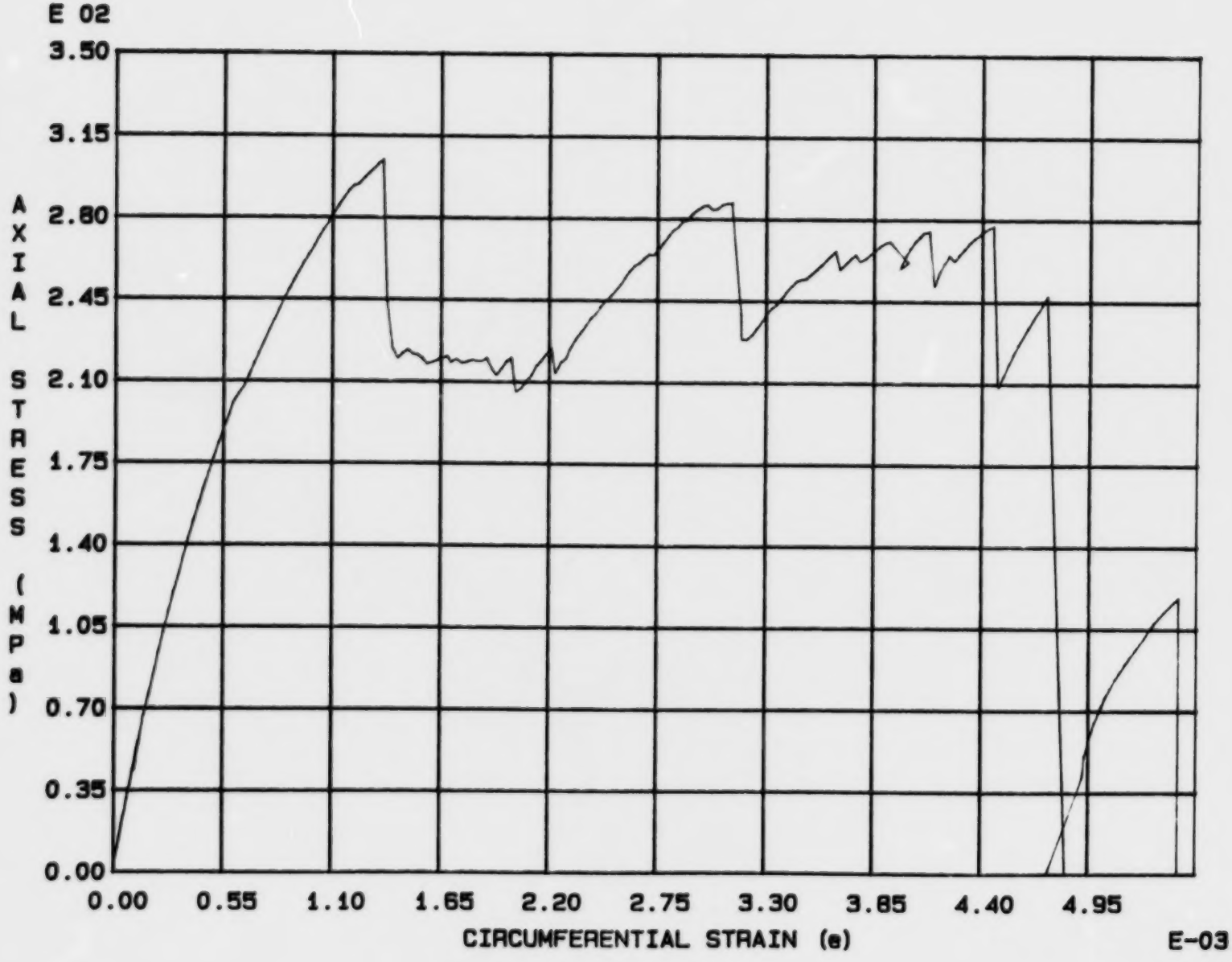

E 02
3.50
3.15
2.80
2.45
2.10
1.75
1.40
1.05
0.70
0.35
0.00
AXIAL STRESS (MPa)
0.00
0.55
1.10
1.65
2.20
2.75
3.30
3.85
4.40
4.95
CIRCUMFERENTIAL STRAIN (e)
E-03

Fig. B-35 E74U

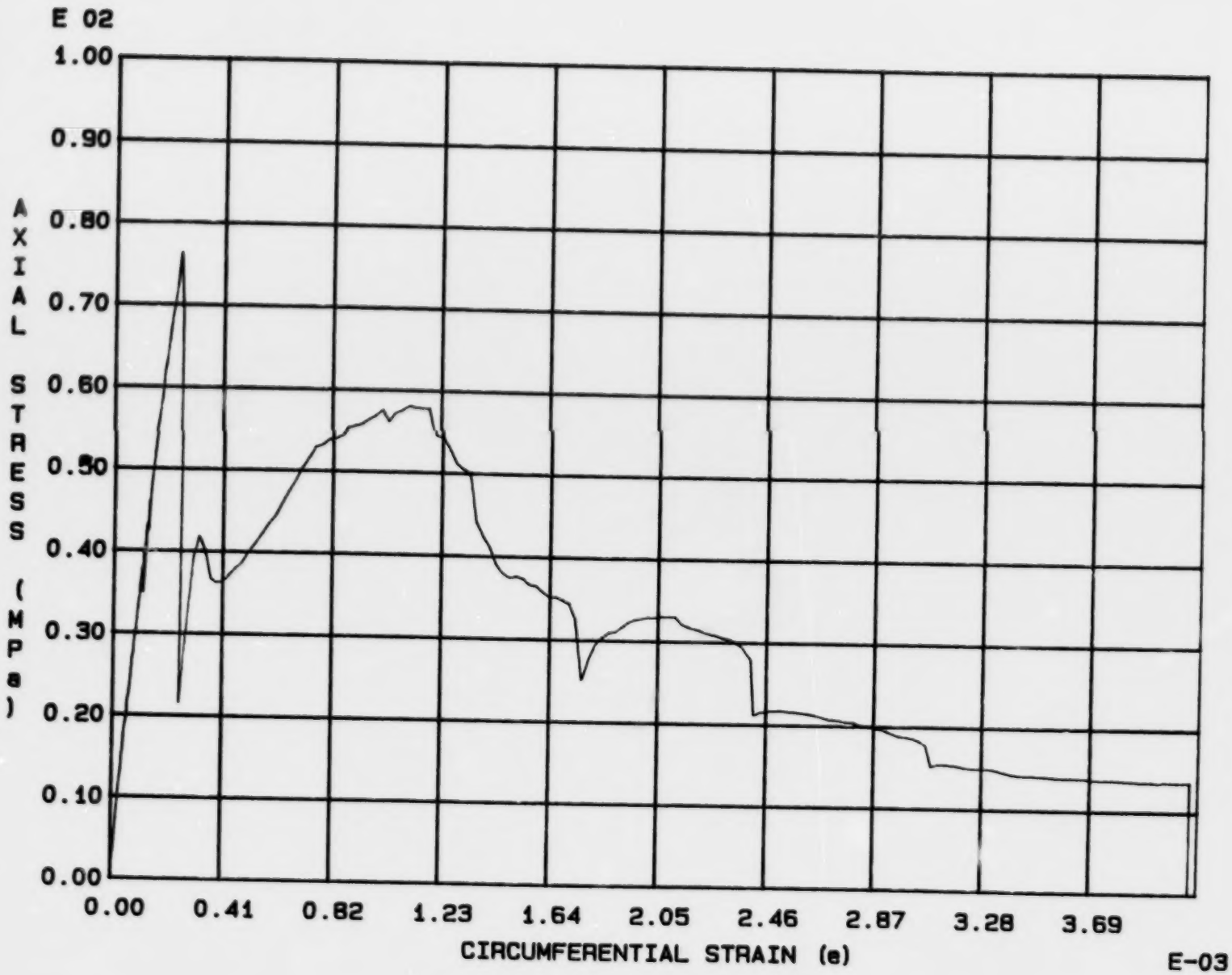

E 02
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
AXIAL STRESS (MPa)
0.00
0.41
0.82
1.23
1.64
2.05
2.46
2.87
3.28
3.69
CIRCUMFERENTIAL STRAIN (e)
E-03

Fig. B-36 E75U

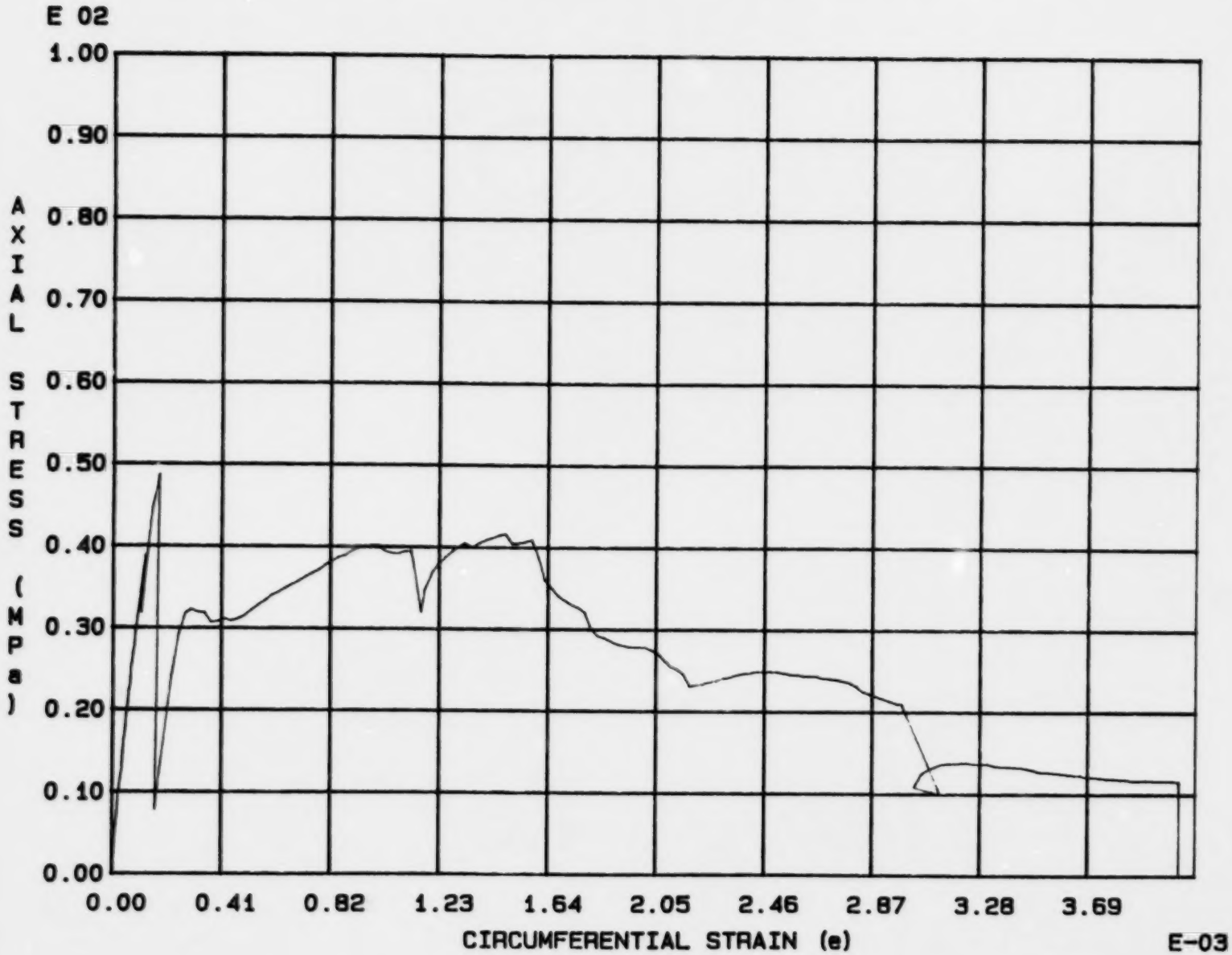

E 02
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
AXIAL STRESS (MPa)
0.00
0.41
0.82
1.23
1.64
2.05
2.46
2.87
3.28
3.69
CIRCUMFERENTIAL STRAIN (e)
E-03

Fig. B-37 E76U

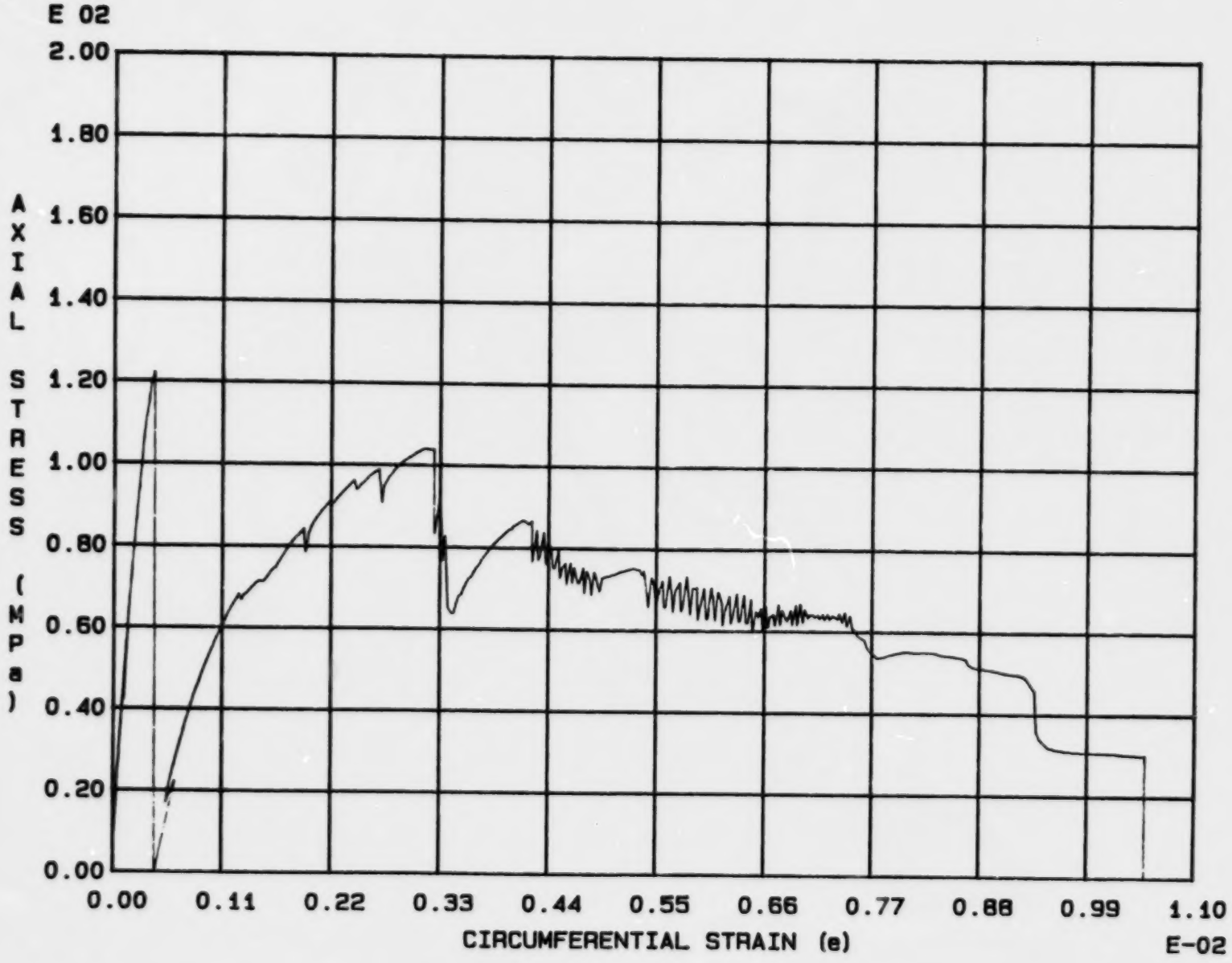

E 02
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
AXIAL STRESS (MPa)
0.00
0.11
0.22
0.33
0.44
0.55
0.66
0.77
0.88
0.99
1.10
CIRCUMFERENTIAL STRAIN (e)
E-02

Fig. B-38 E77U

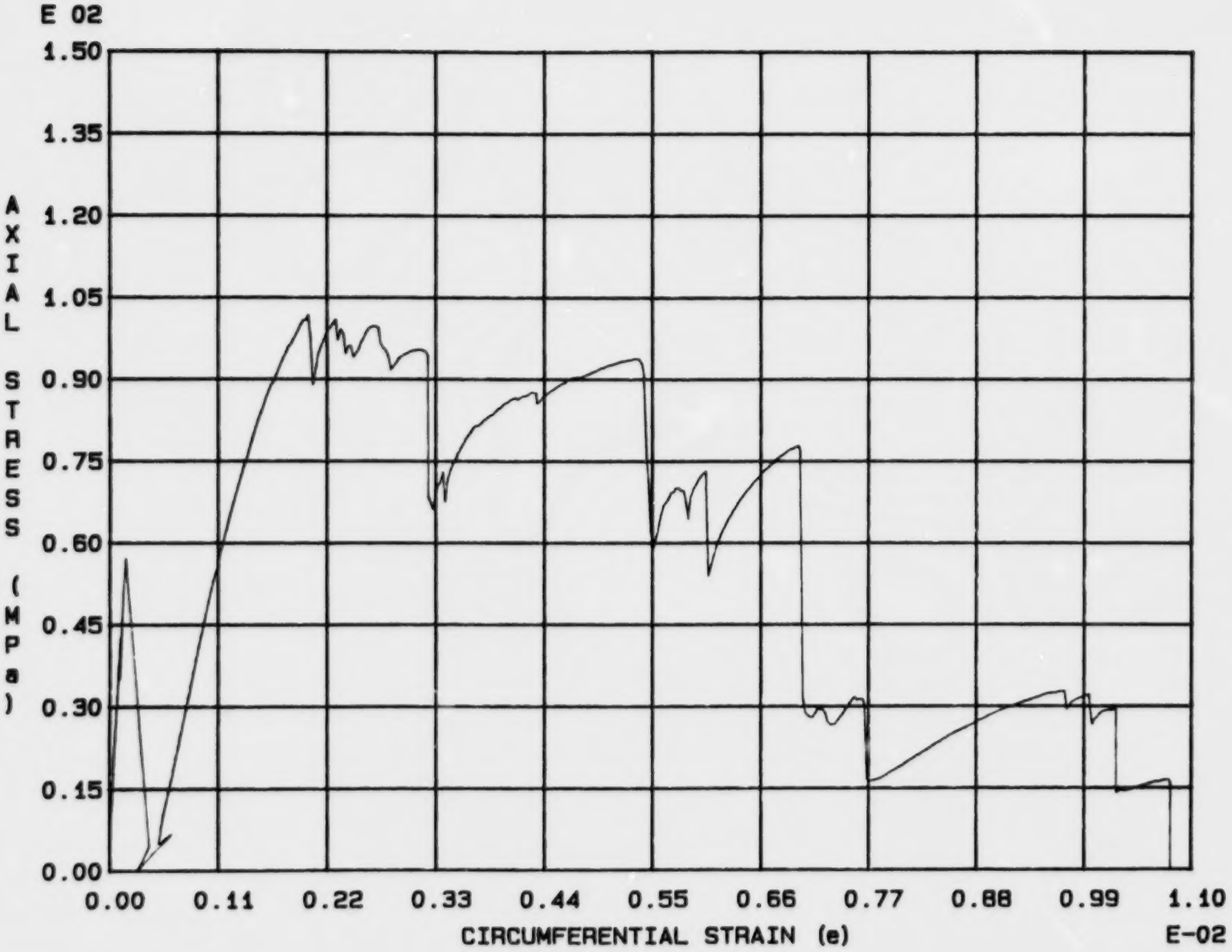

E 02
1.50
1.35
1.20
1.05
0.90
0.75
0.60
0.45
0.30
0.15
0.00
AXIAL STRESS (MPa)
0.00
0.11
0.22
0.33
0.44
0.55
0.66
0.77
0.88
0.99
1.10
CIRCUMFERENTIAL STRAIN (e)
E-02

Fig. B-39 E78U

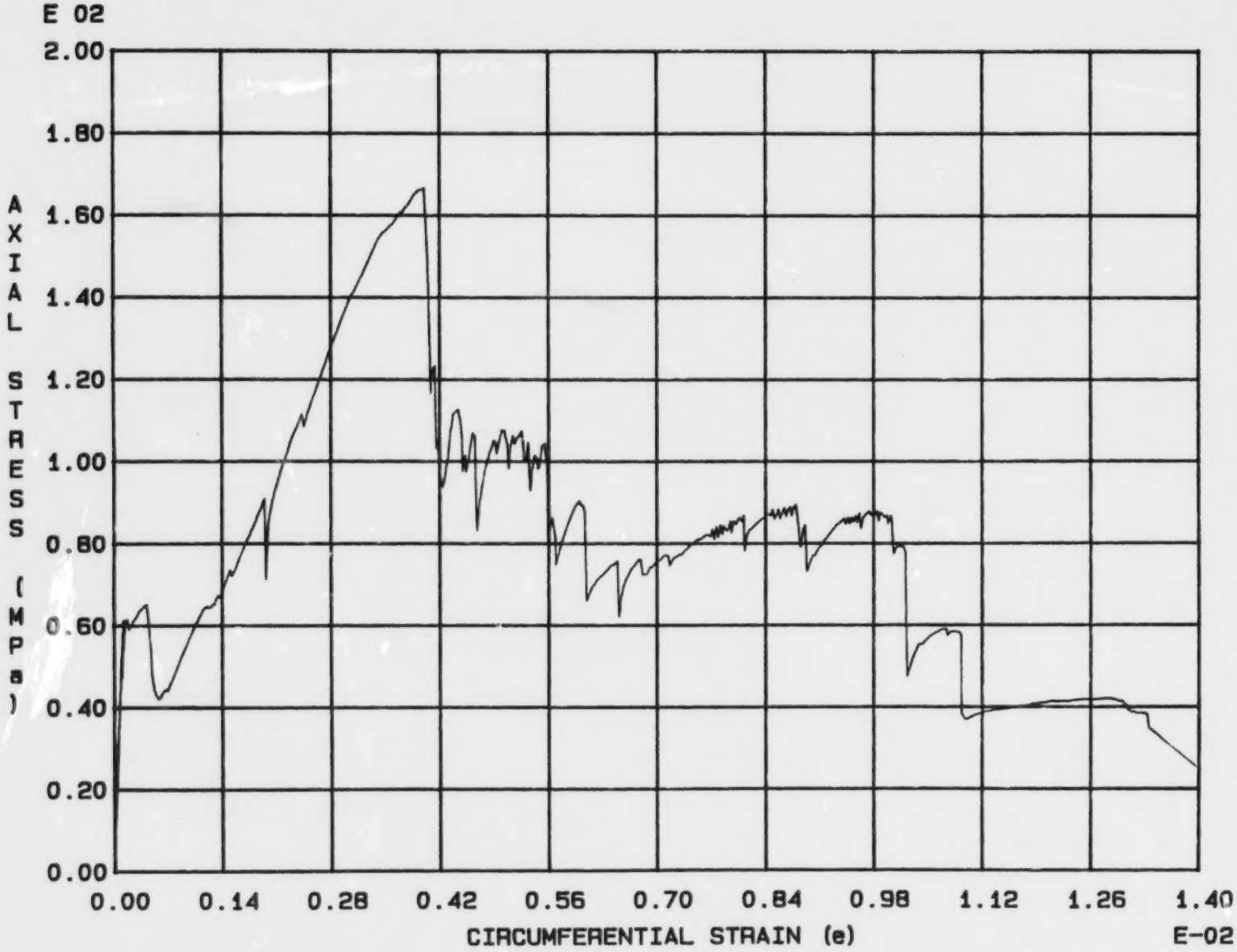

E 02
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
AXIAL STRESS (MPa)
0.00
0.14
0.28
0.42
0.56
0.70
0.84
0.98
1.12
1.26
1.40
CIRCUMFERENTIAL STRAIN (e)
E-02

Fig. B-40 E79U

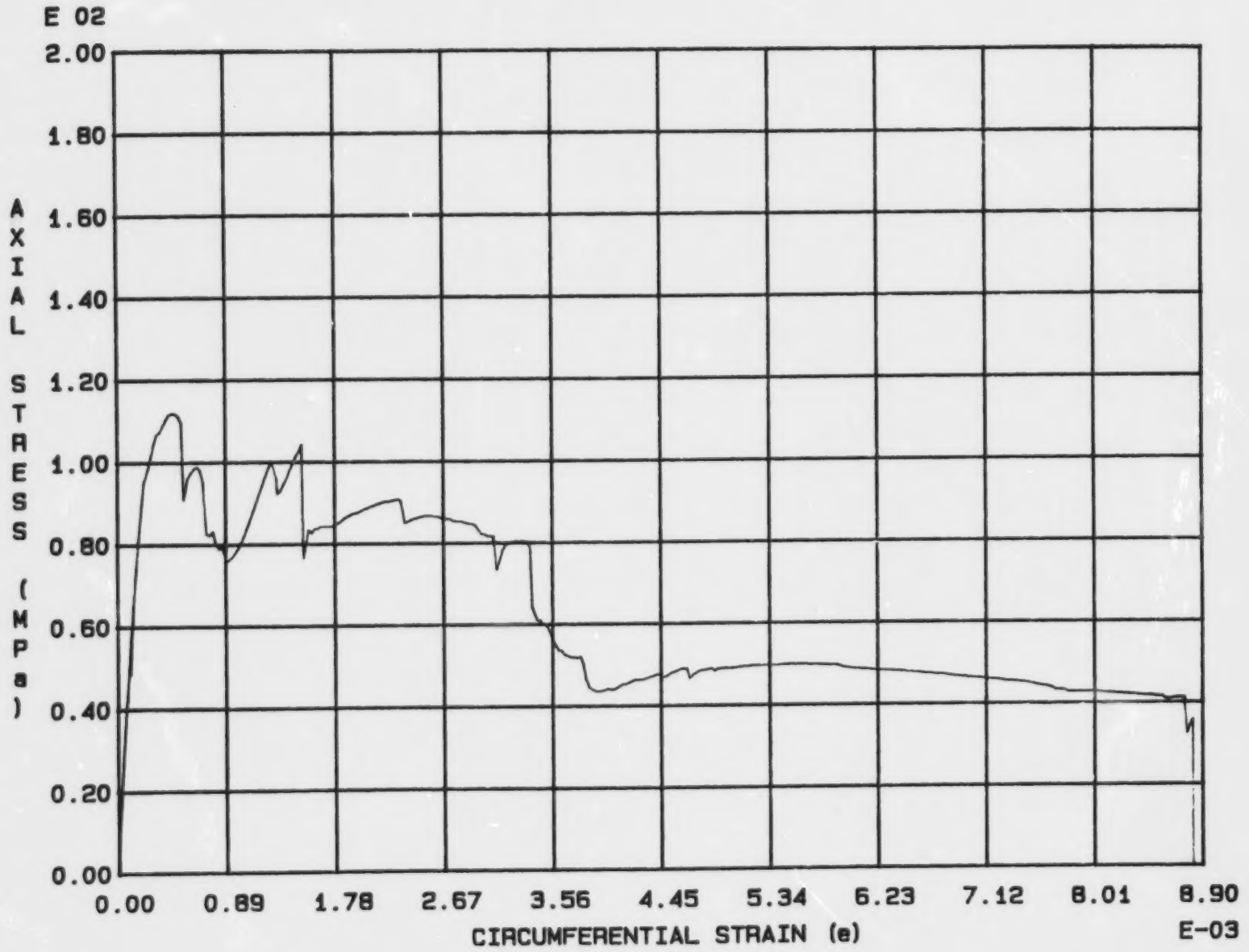

E 02
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
AXIAL STRESS (MPa)
0.00
0.89
1.78
2.67
3.56
4.45
5.34
6.23
7.12
8.01
8.90
E-03
CIRCUMFERENTIAL STRAIN (e)

Fig. B-41 E80U

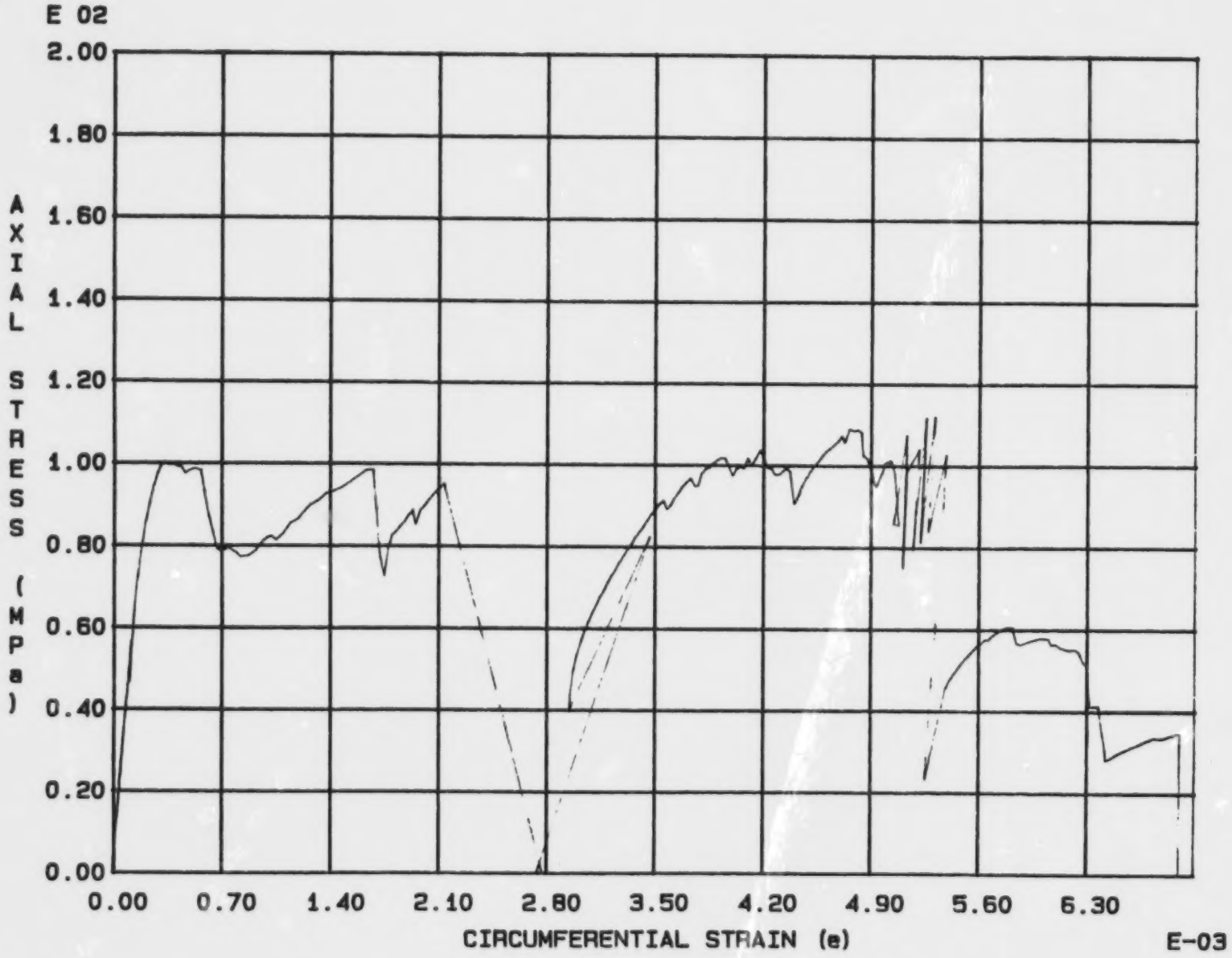

E 02
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
AXIAL STRESS (MPa)
0.00
0.70
1.40
2.10
2.80
3.50
4.20
4.90
5.60
6.30
CIRCUMFERENTIAL STRAIN (e)
E-03

Fig. B-42 E81U

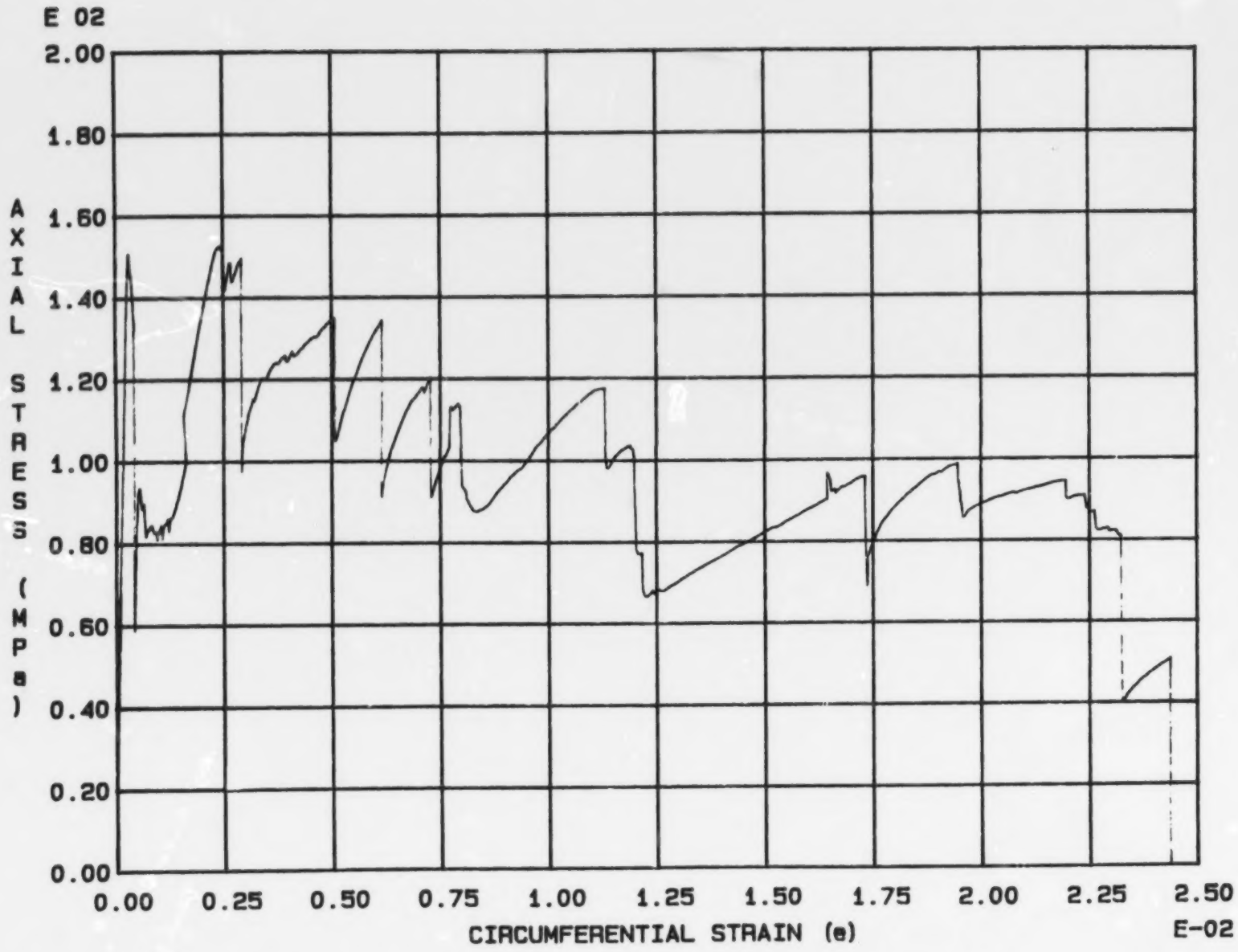

E 02
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
AXIAL STRESS (MPa)
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00
2.25
2.50
CIRCUMFERENTIAL STRAIN (e)
E-02

Fig. B-43 E82U

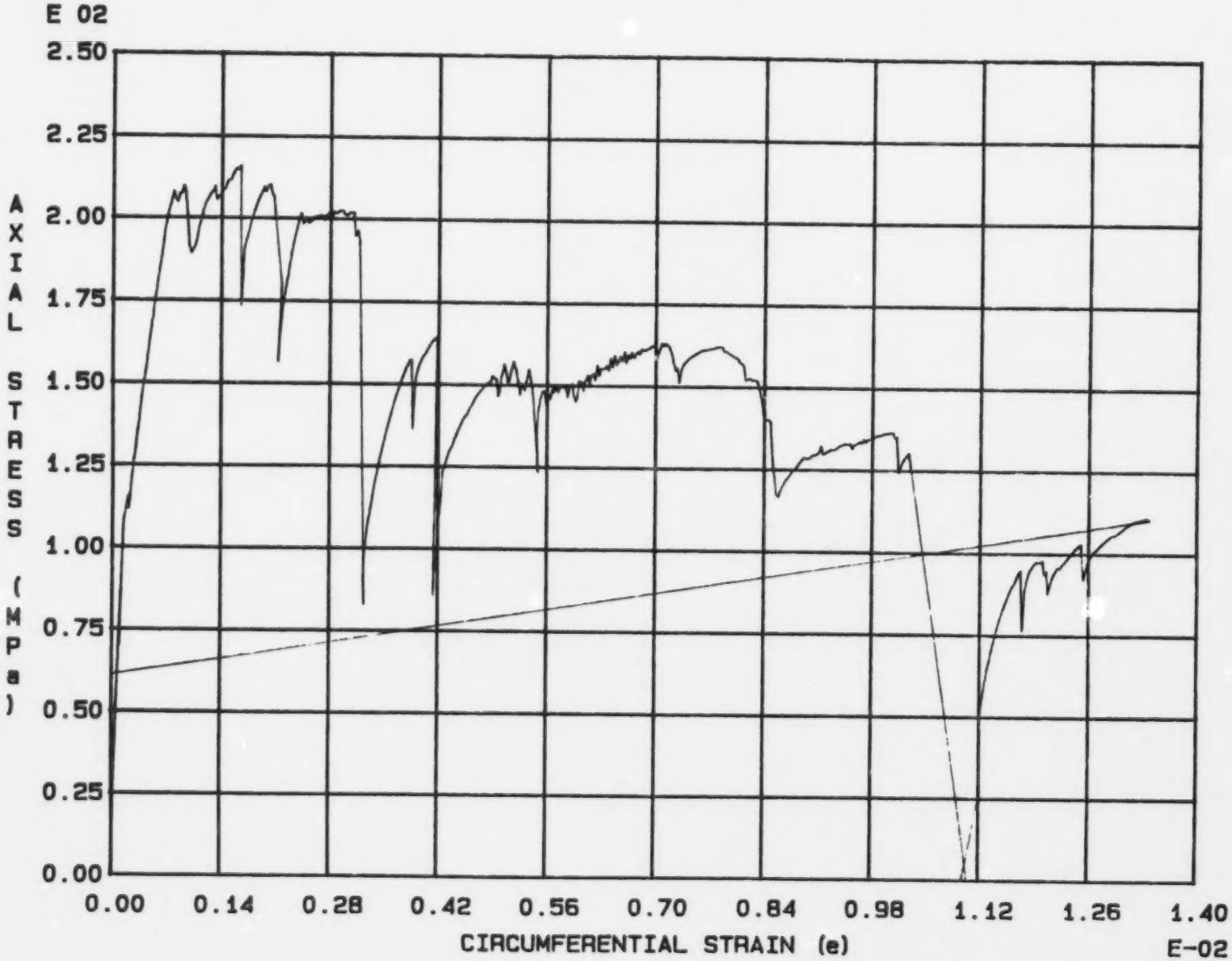

E 02
2.50
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
AXIAL STRESS (MPa)
0.00
0.14
0.28
0.42
0.56
0.70
0.84
0.98
1.12
1.26
1.40
CIRCUMFERENTIAL STRAIN (e)
E-02

Fig. B-44 E83U

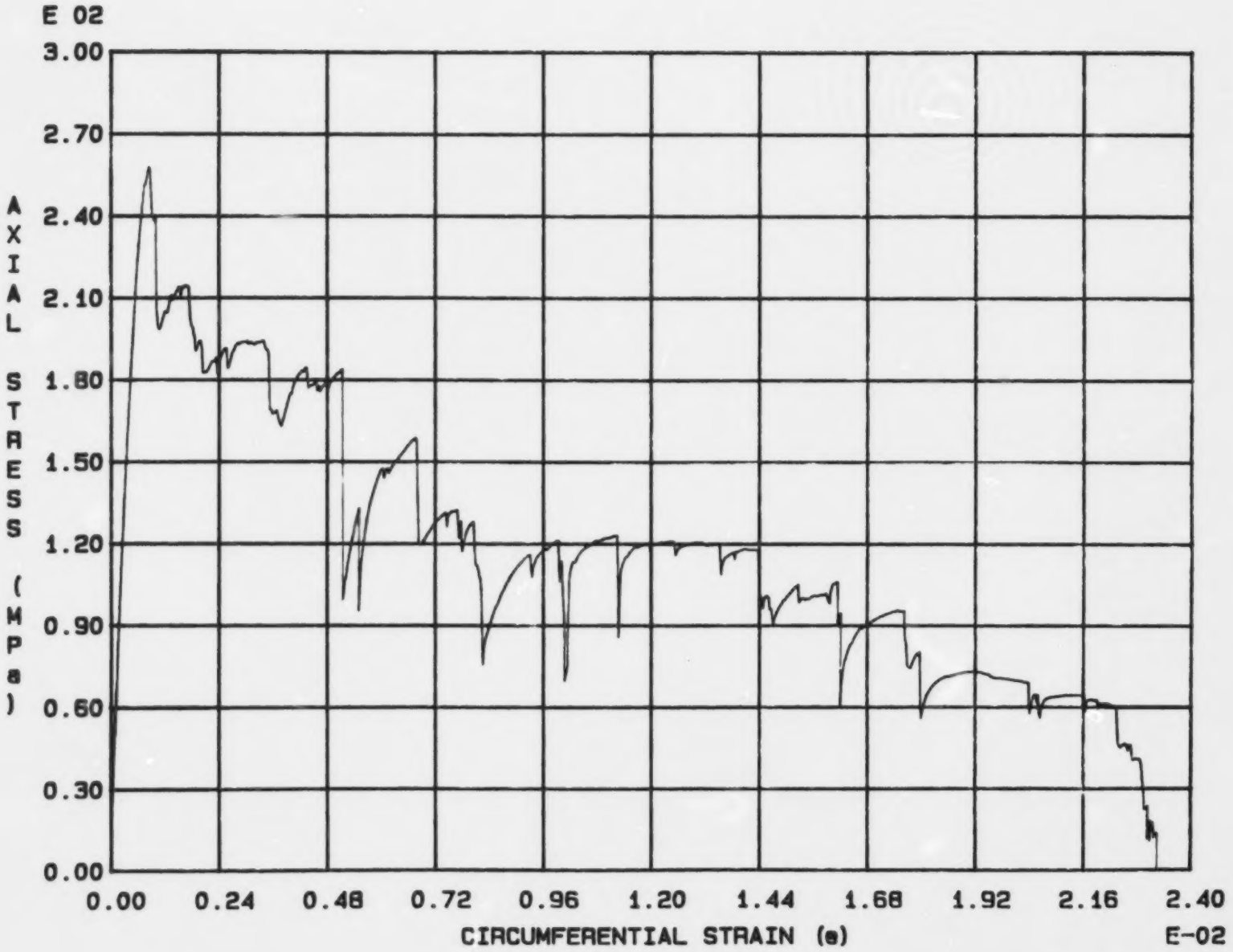

E 02
3.00
2.70
2.40
2.10
1.80
1.50
1.20
0.90
0.60
0.30
0.00
AXIAL STRESS (MPa)
0.00
0.24
0.48
0.72
0.96
1.20
1.44
1.68
1.92
2.16
2.40
CIRCUMFERENTIAL STRAIN (e)
E-02

Fig. B-45 E84U

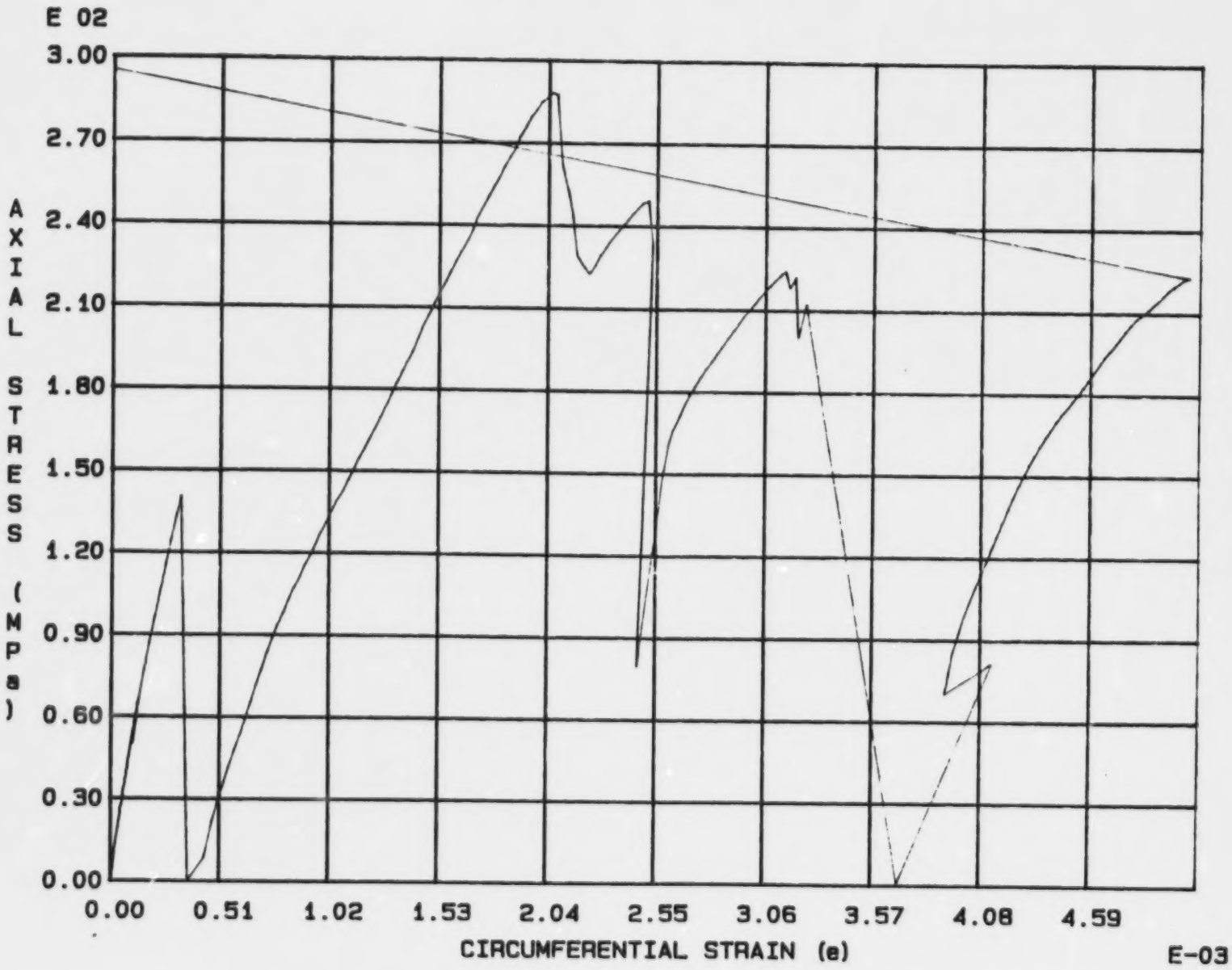

E 02
3.00
2.70
2.40
2.10
1.80
1.50
1.20
0.90
0.60
0.30
0.00
AXIAL STRESS (MPa)
0.00
0.51
1.02
1.53
2.04
2.55
3.06
3.57
4.08
4.59
CIRCUMFERENTIAL STRAIN (e)
E-03

Fig. B-46 E85U

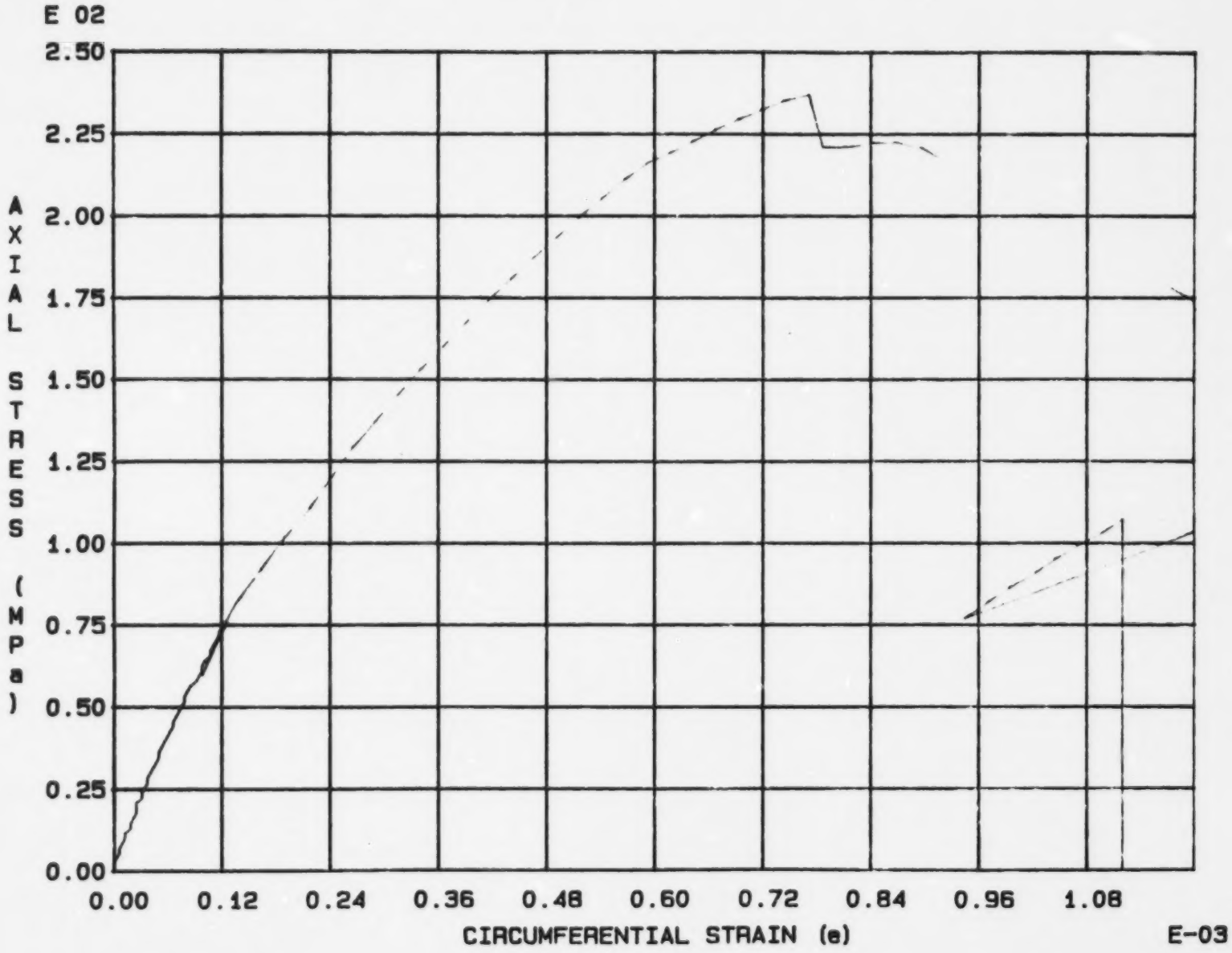

E 02
2.50
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
AXIAL STRESS (MPa)
0.00
0.12
0.24
0.36
0.48
0.60
0.72
0.84
0.96
1.08
CIRCUMFERENTIAL STRAIN (e)
E-03

Fig. B-47 E86U

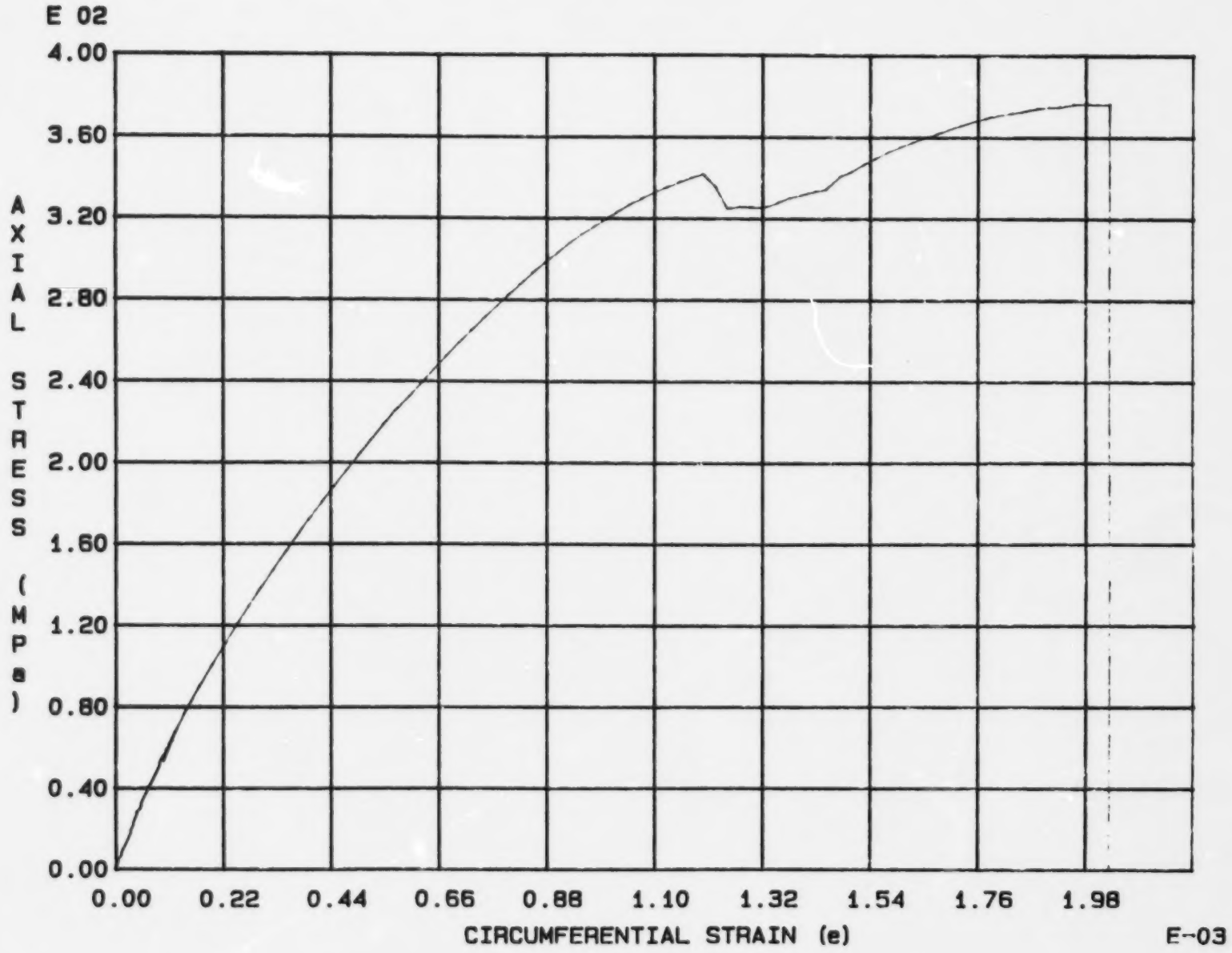

E 02
4.00
3.60
3.20
2.80
2.40
2.00
1.60
1.20
0.80
0.40
0.00
AXIAL STRESS (MPa)
0.00
0.22
0.44
0.66
0.88
1.10
1.32
1.54
1.76
1.98
CIRCUMFERENTIAL STRAIN (e)
E-03

Fig. B-48 E87U

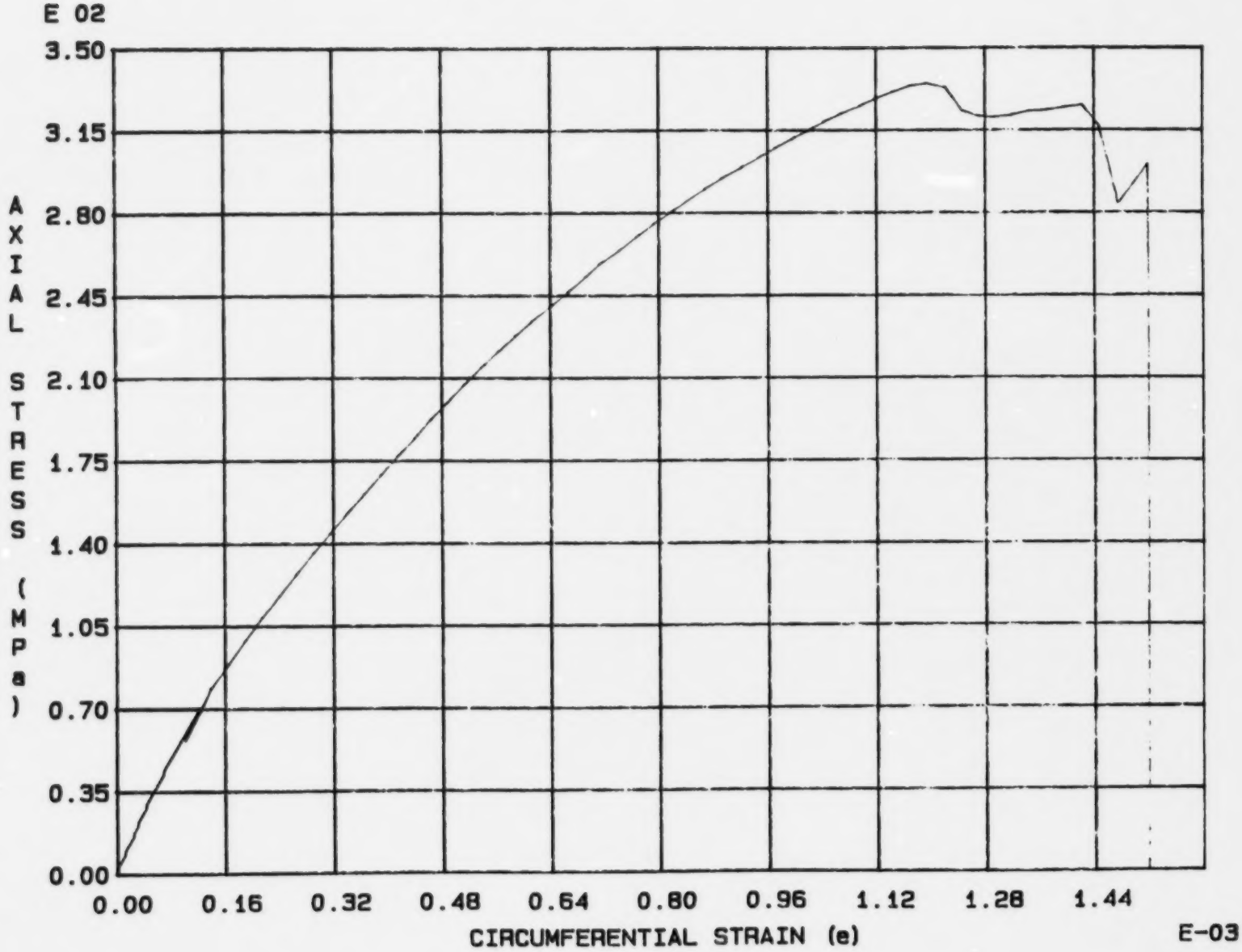

E 02
3.50
3.15
2.80
2.45
2.10
1.75
1.40
1.05
0.70
0.35
0.00
AXIAL STRESS (MPa)
0.00
0.16
0.32
0.48
0.64
0.80
0.96
1.12
1.28
1.44
CIRCUMFERENTIAL STRAIN (e)
E-03

Fig. B-49 E88U

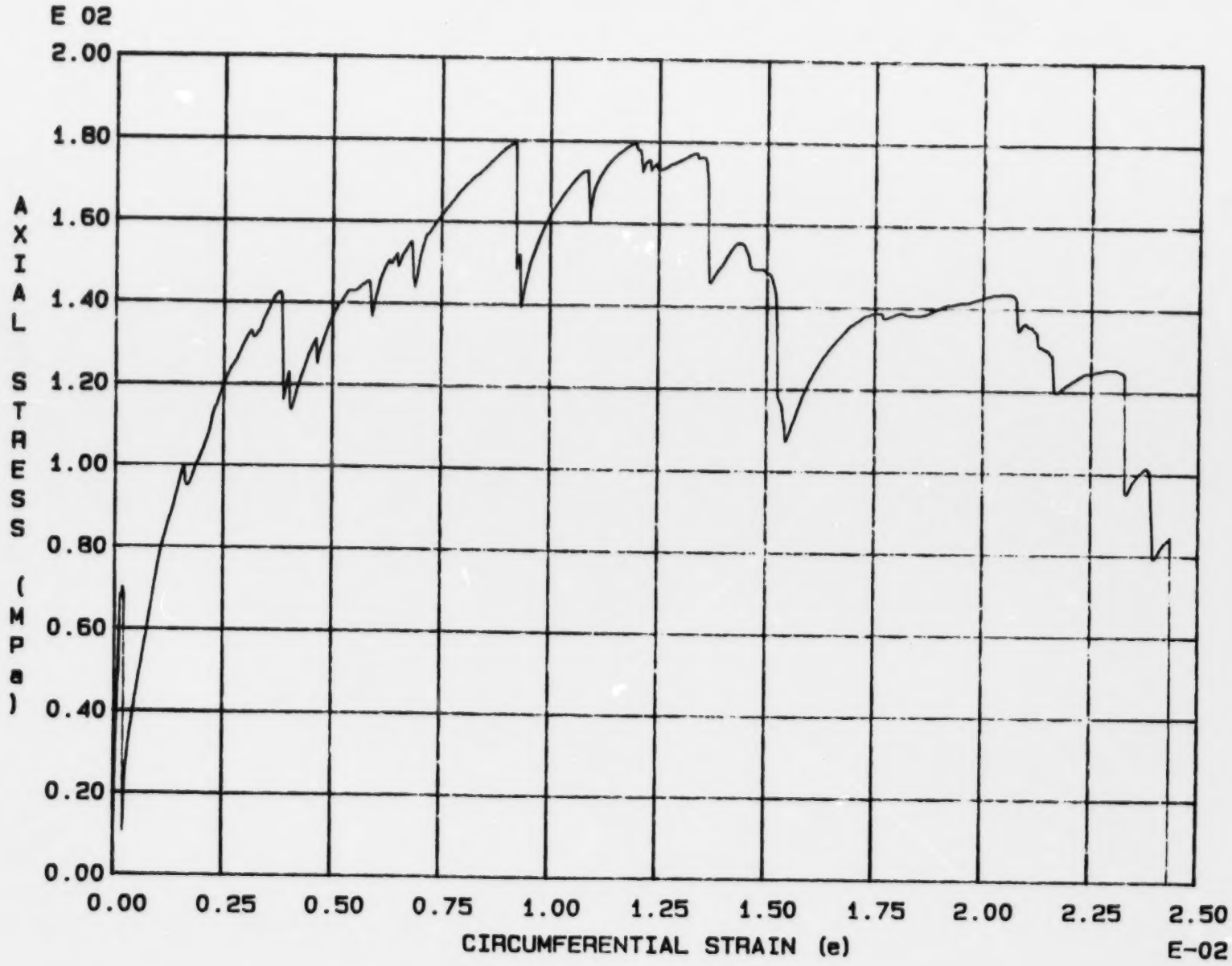

E 02
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
AXIAL STRESS (MPa)
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00
2.25
2.50
CIRCUMFERENTIAL STRAIN (e)
E-02

Fig. B-50 E89U

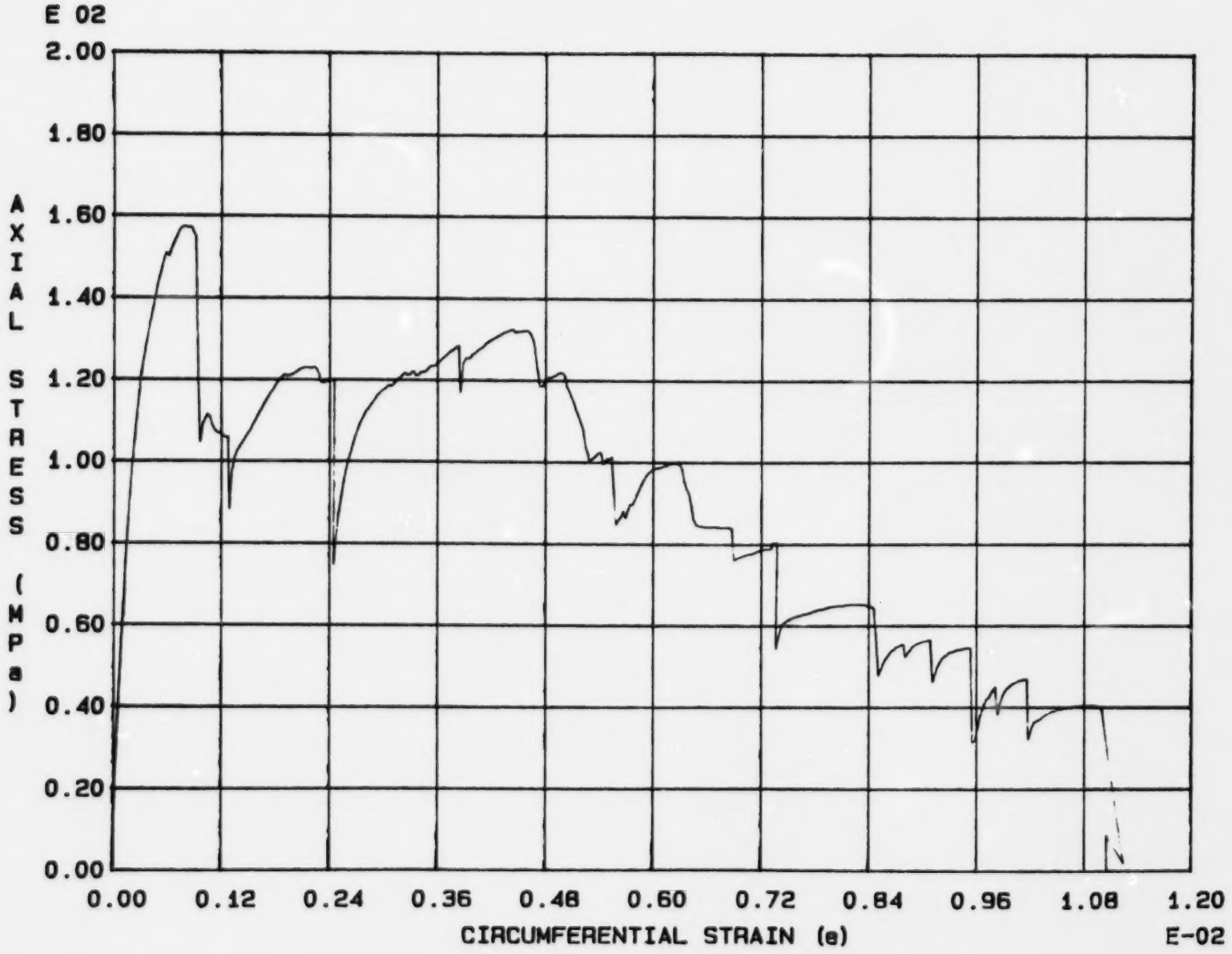

E 02
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
AXIAL STRESS (MPa)
0.00
0.12
0.24
0.36
0.48
0.60
0.72
0.84
0.96
1.08
1.20
CIRCUMFERENTIAL STRAIN (e)
E-02

Fig. B-51 E90U

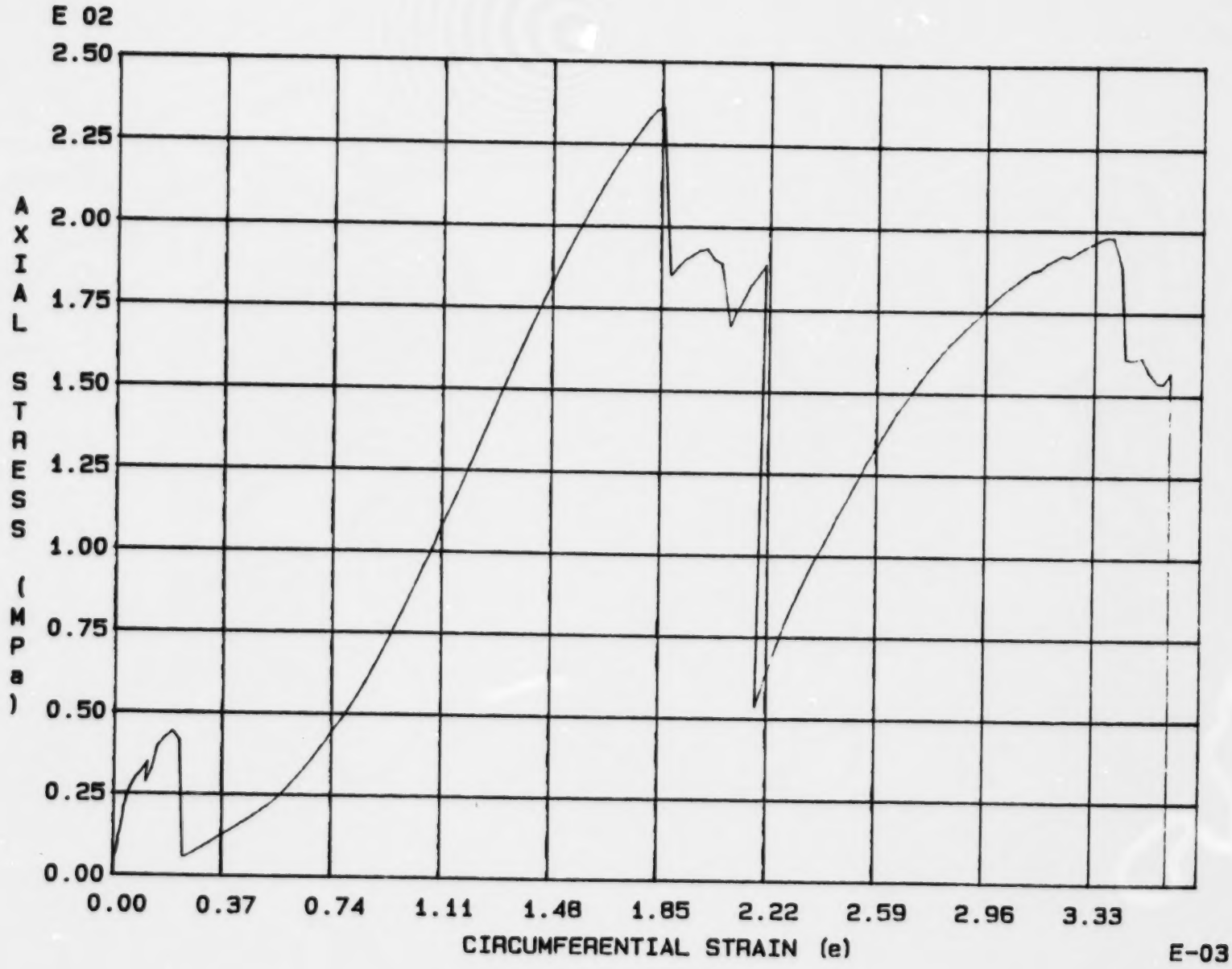

E 02
2.50
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
AXIAL STRESS (MPa)
0.00
0.37
0.74
1.11
1.48
1.85
2.22
2.59
2.96
3.33
CIRCUMFERENTIAL STRAIN (e)
E-03

Fig. B-52 E91U

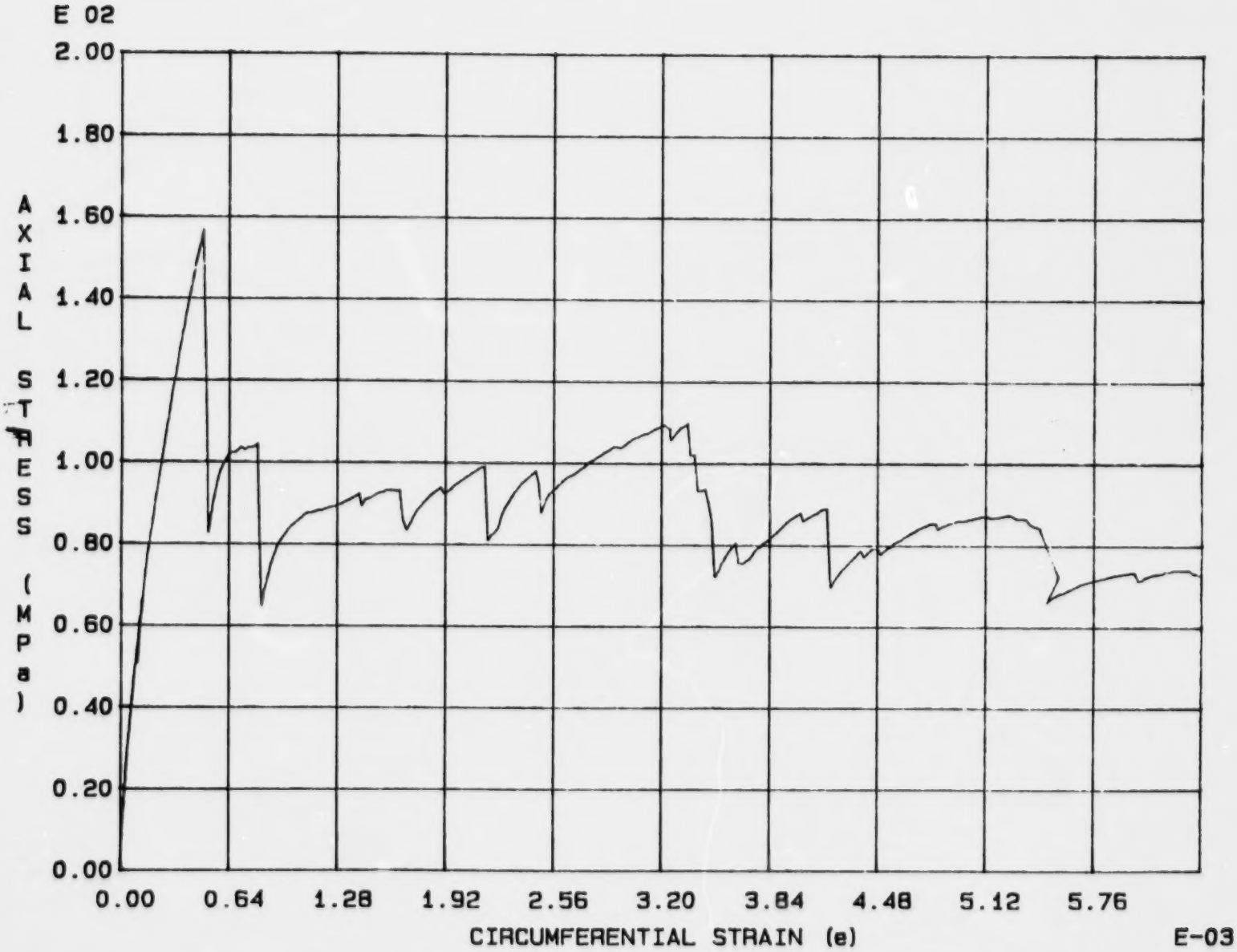


Fig. B-53 E103U

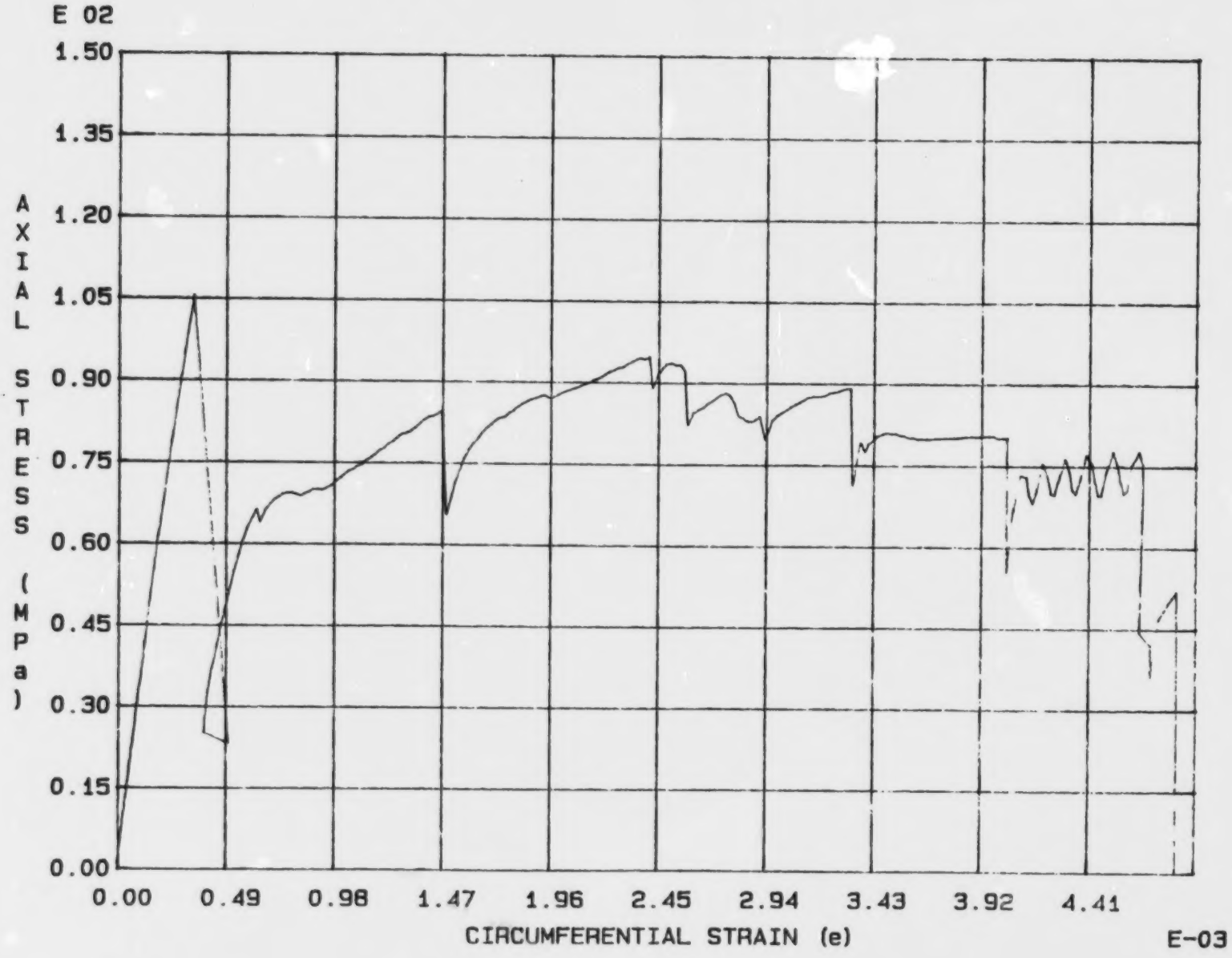


Fig. B-54 E104U

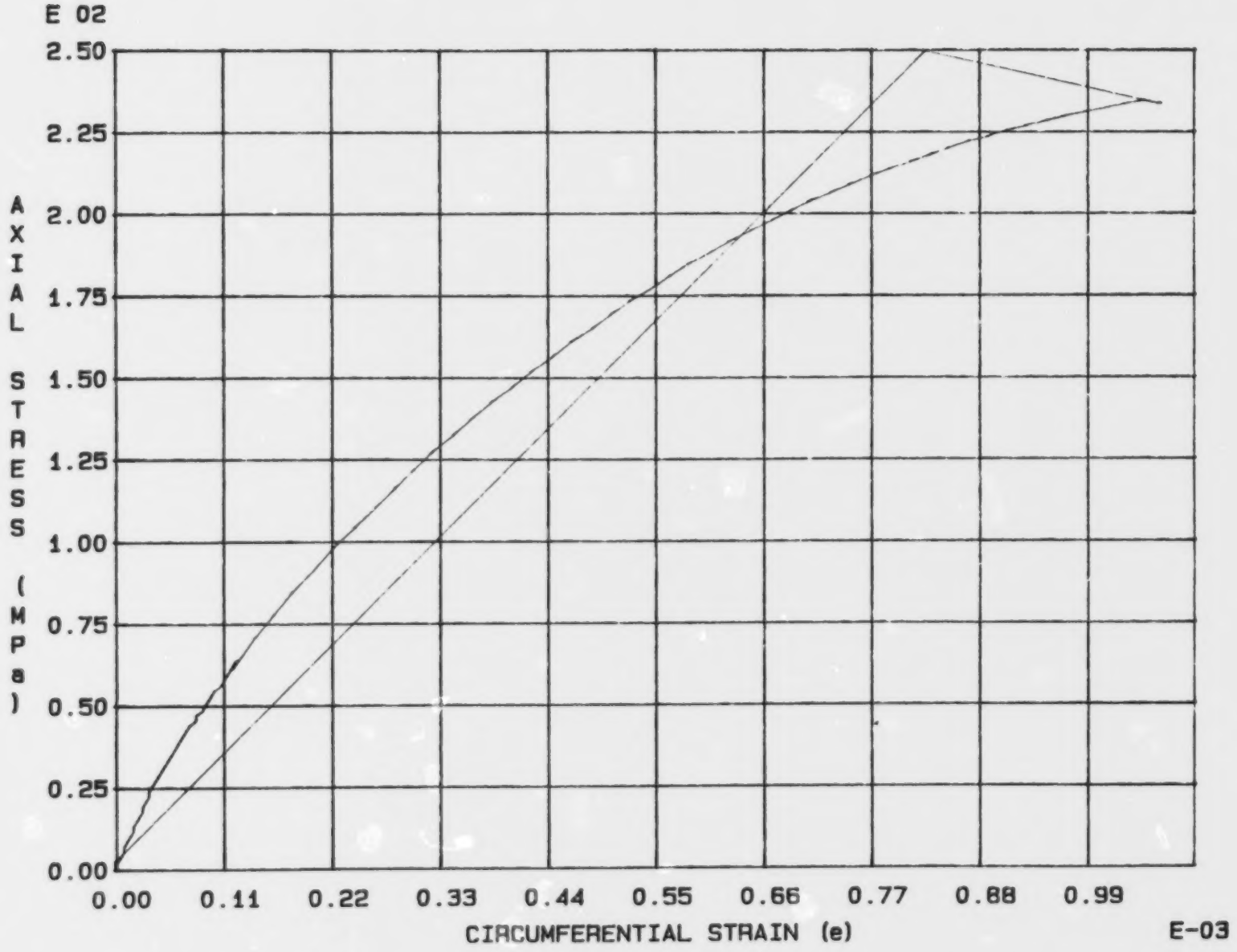


Fig. B-55 E105U

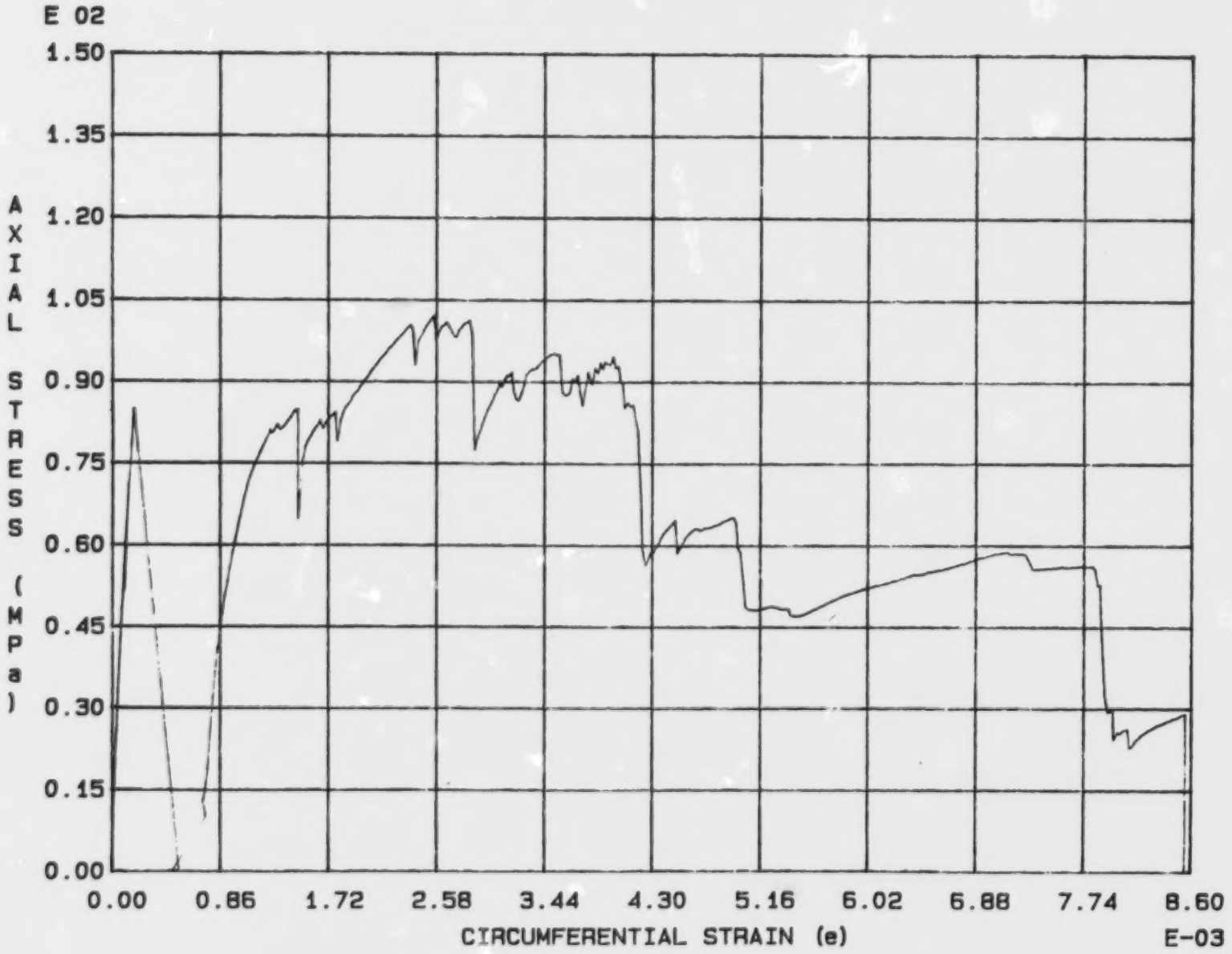


Fig. B-56 E106U

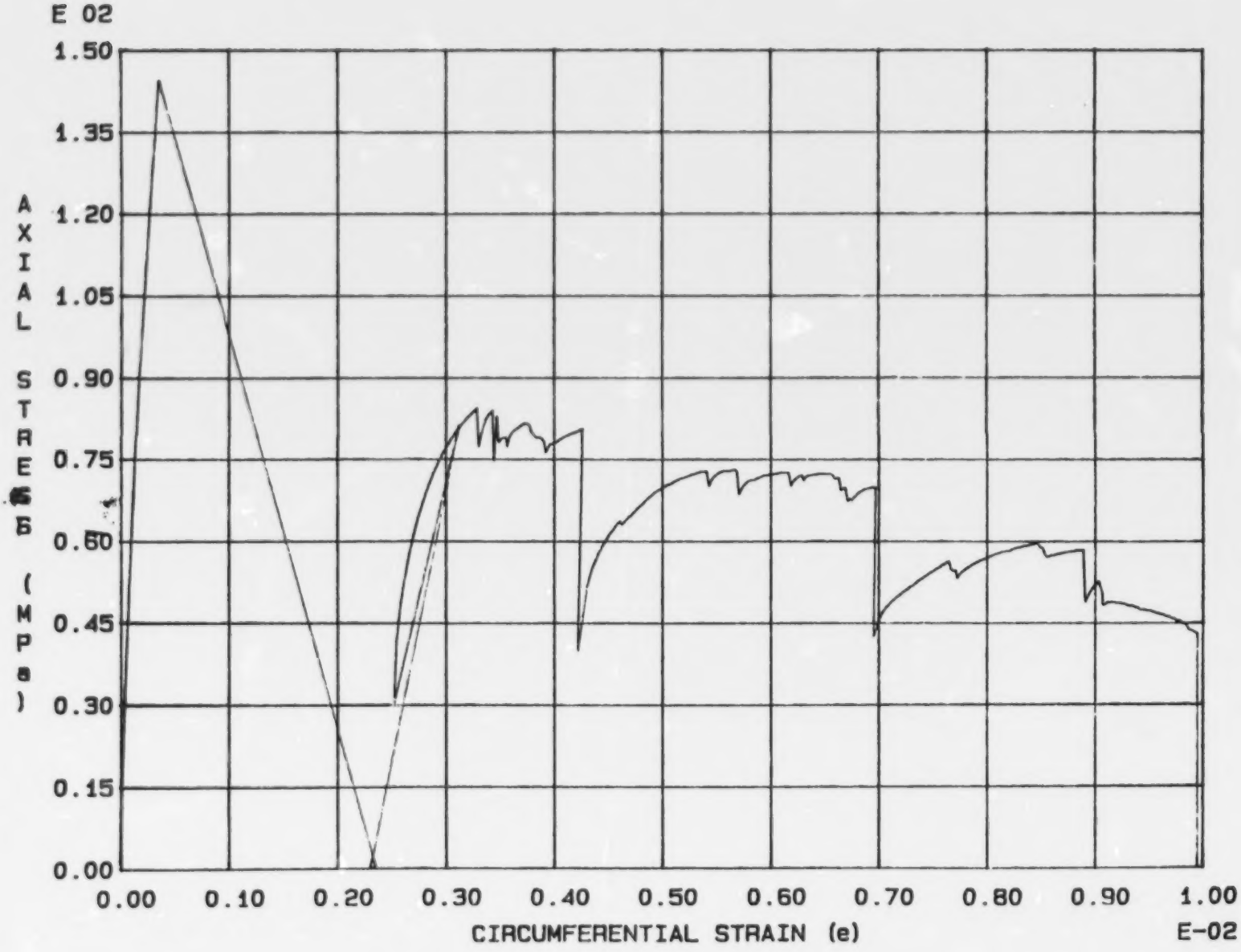


Fig. B-57 E107U

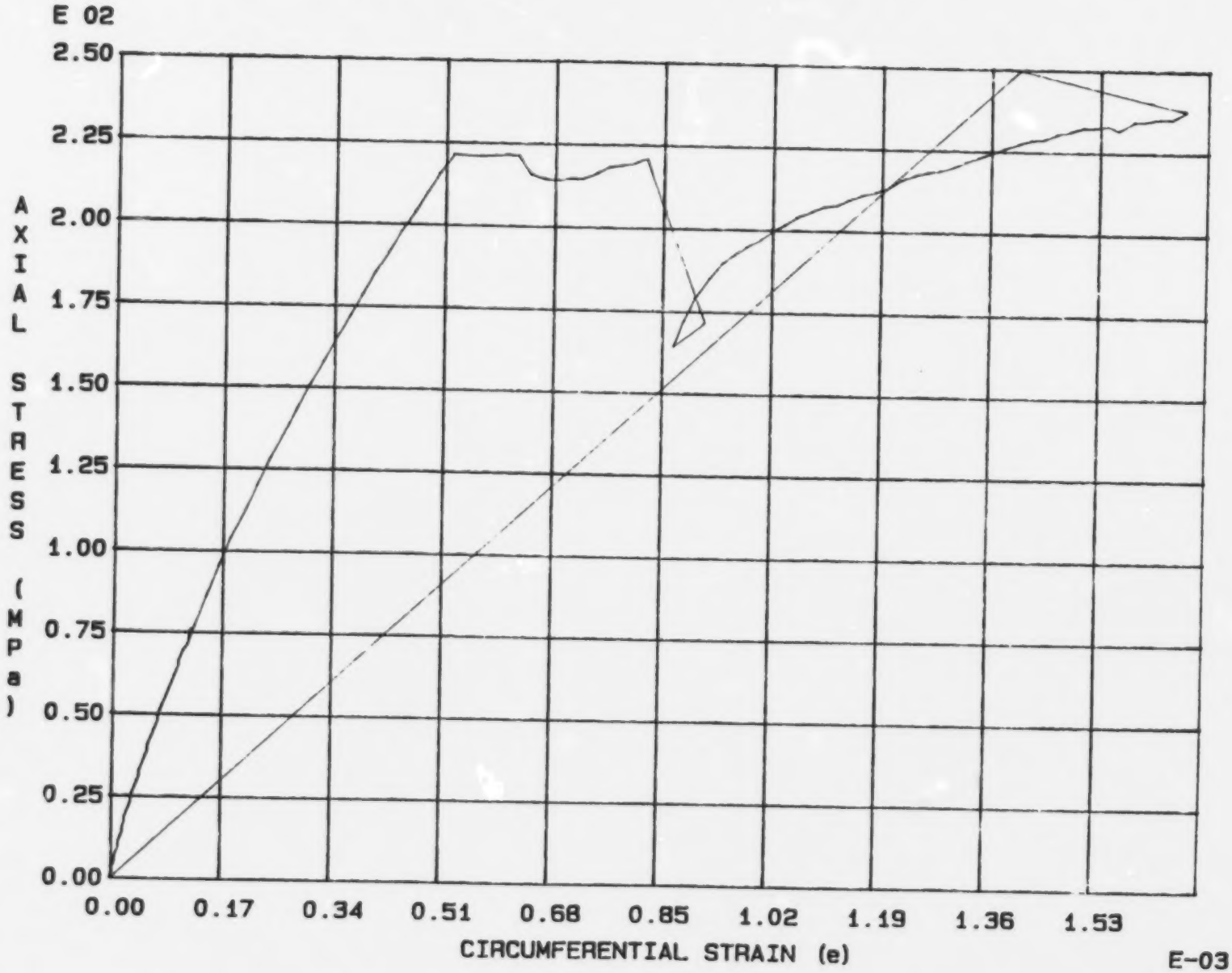


Fig. B-58 E108U

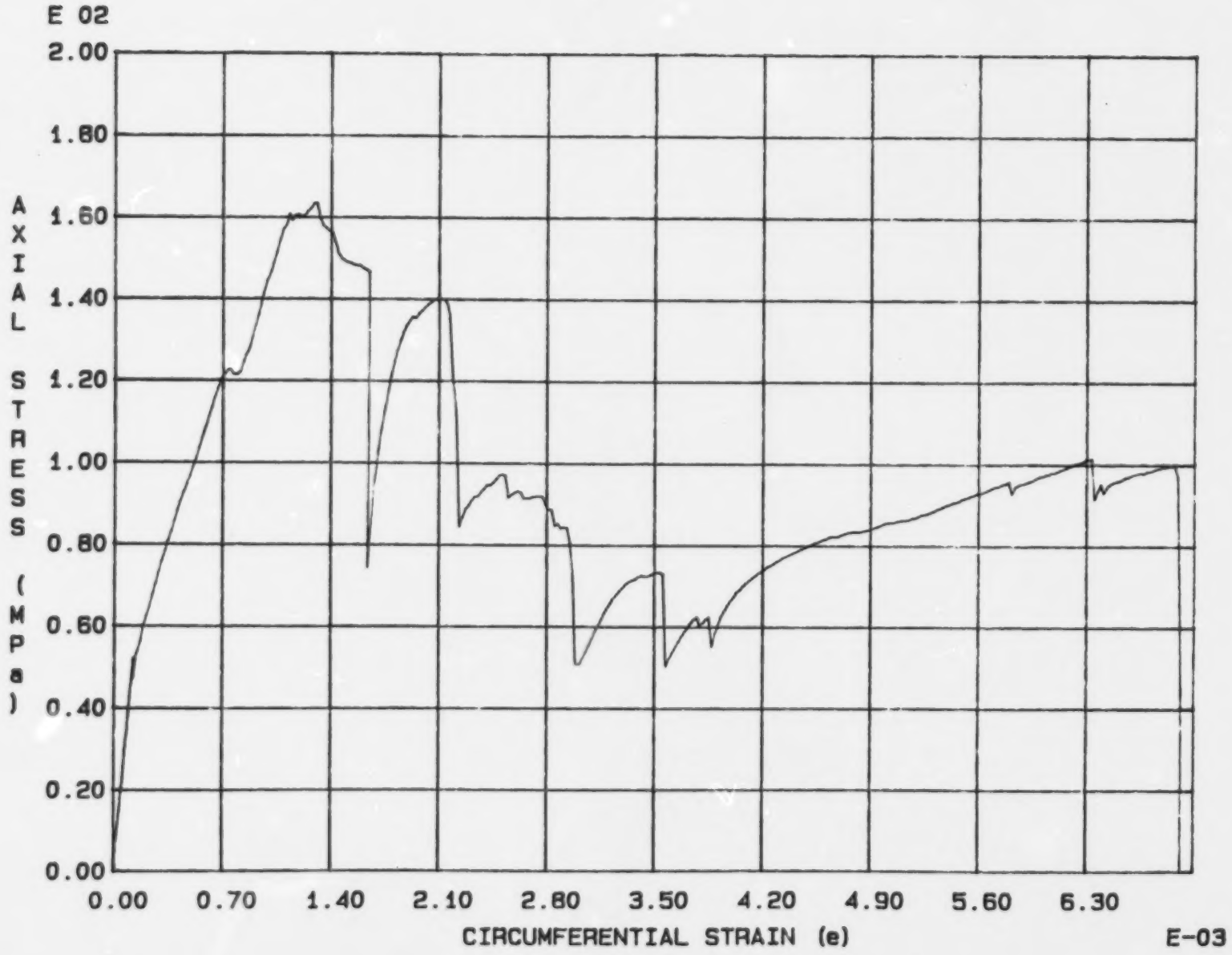


Fig. B-59 E109U

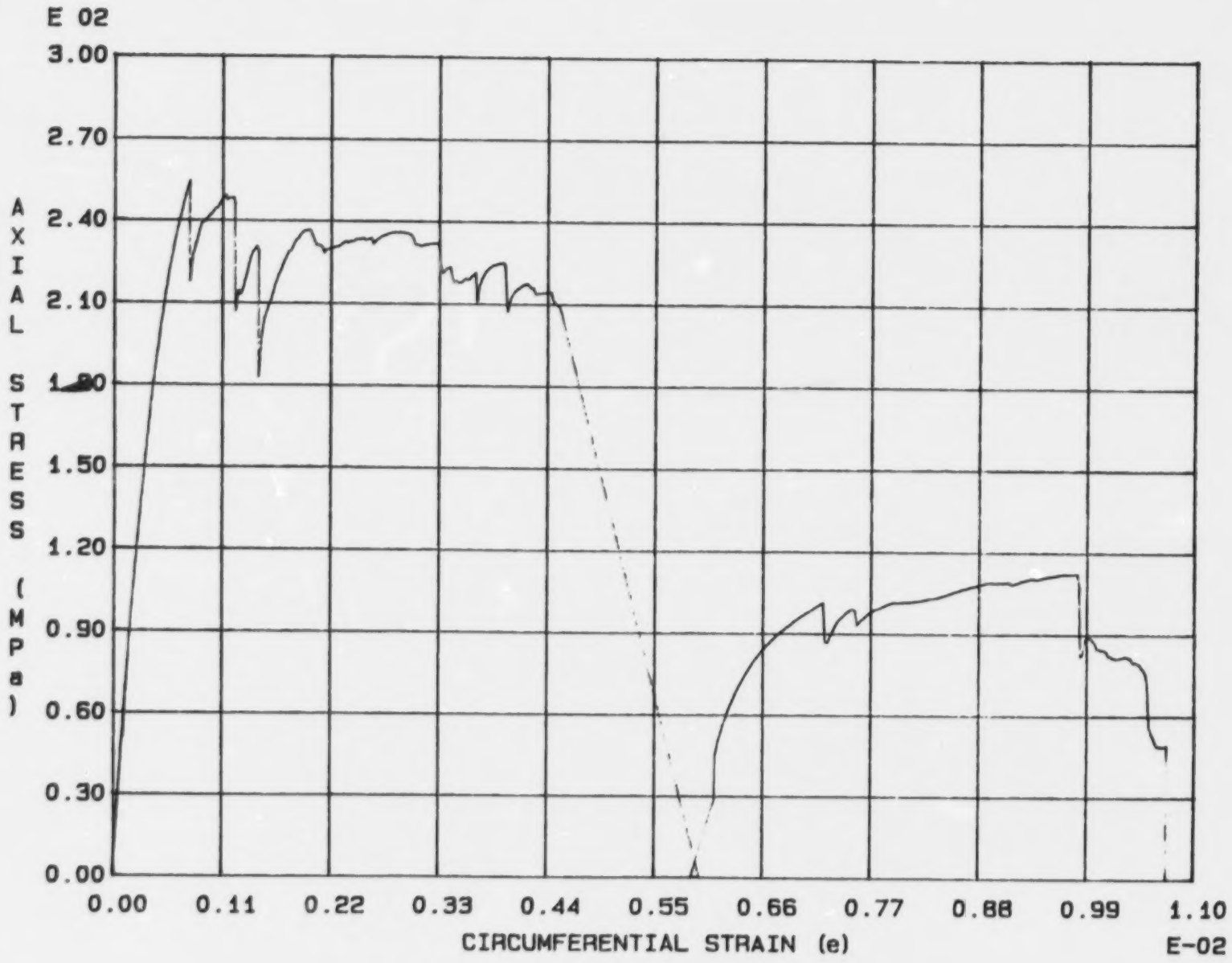


Fig. B-60 E110U

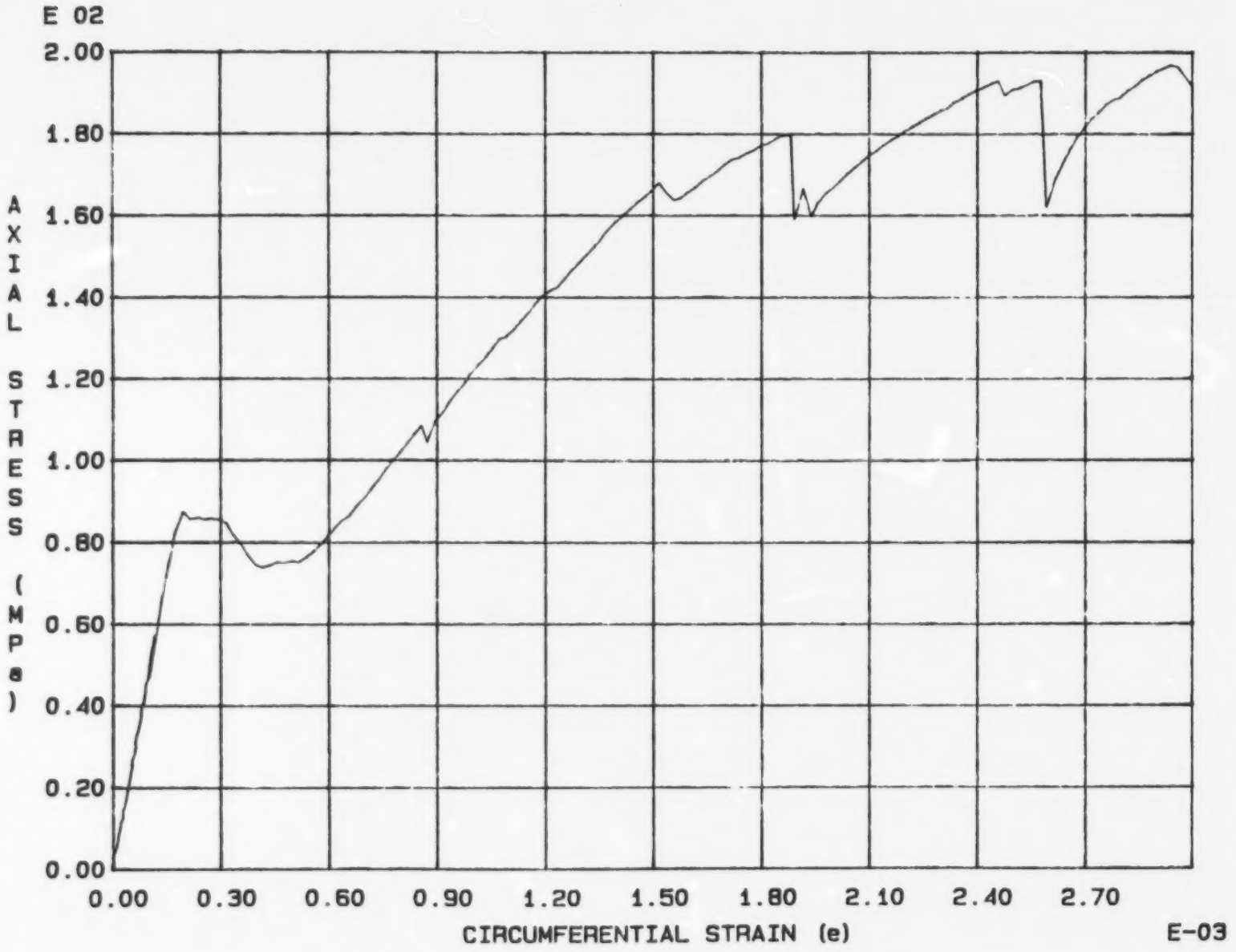


Fig. B-61 E111U

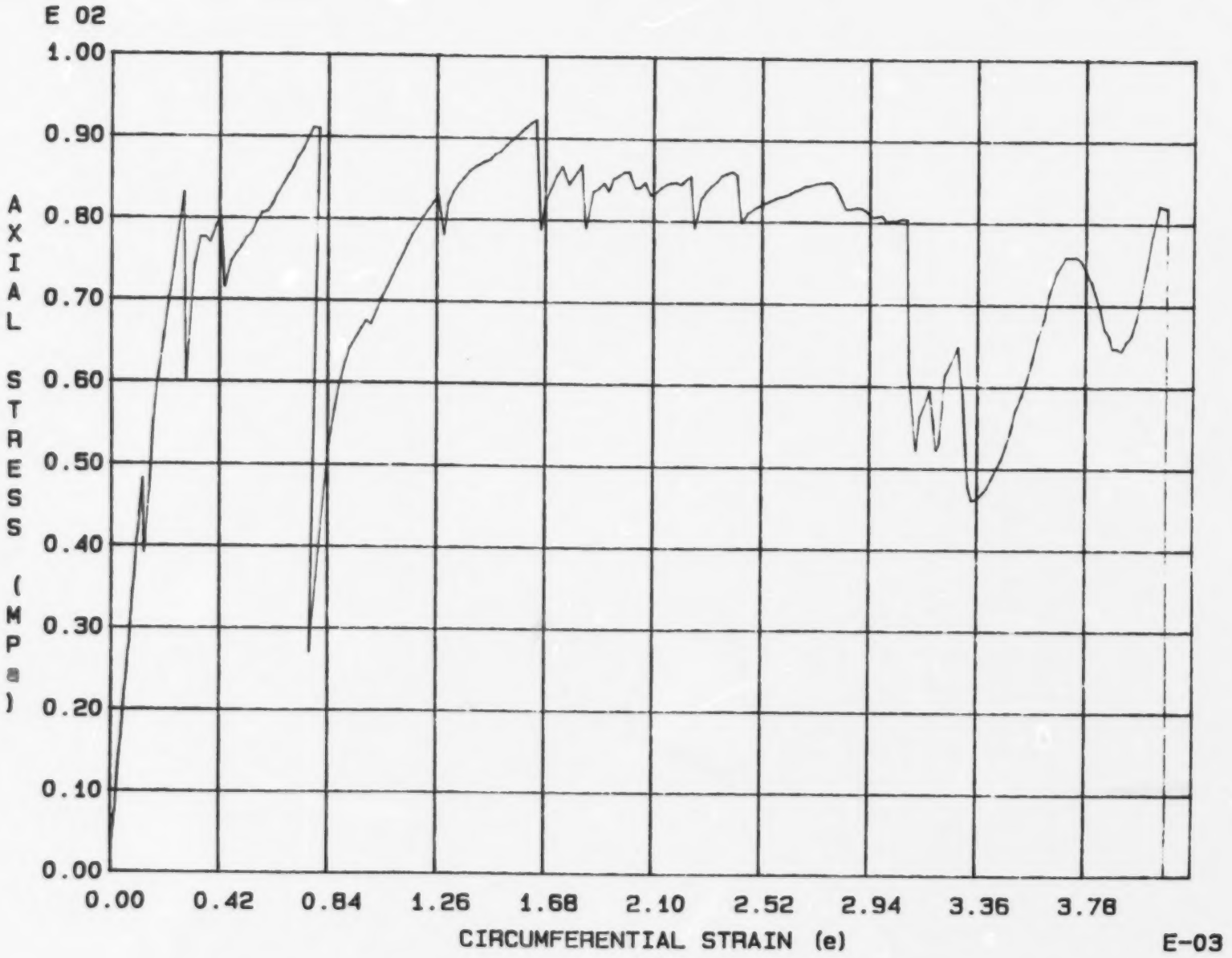


Fig. B-62 E112U

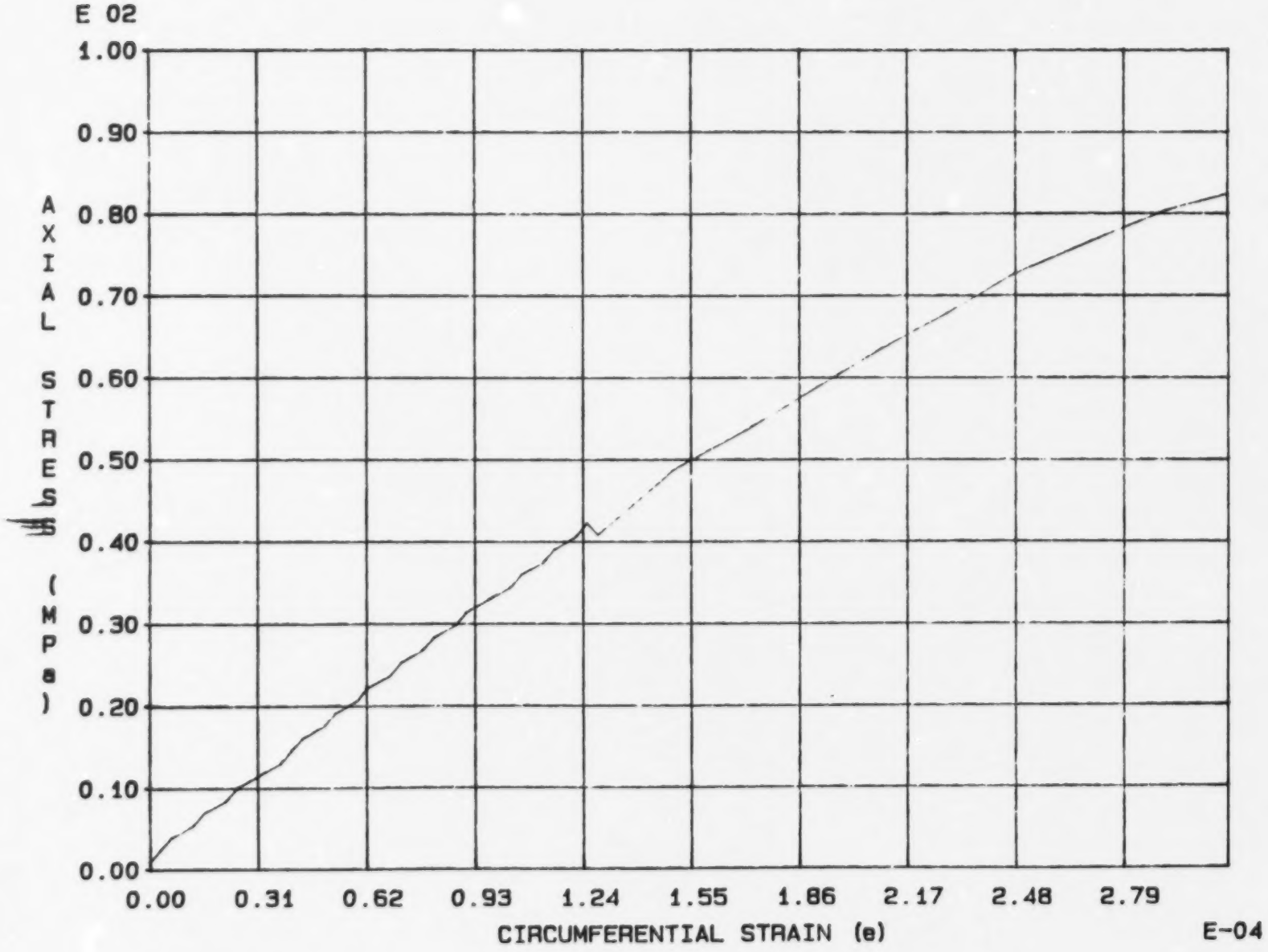


Fig. B-63 E113U

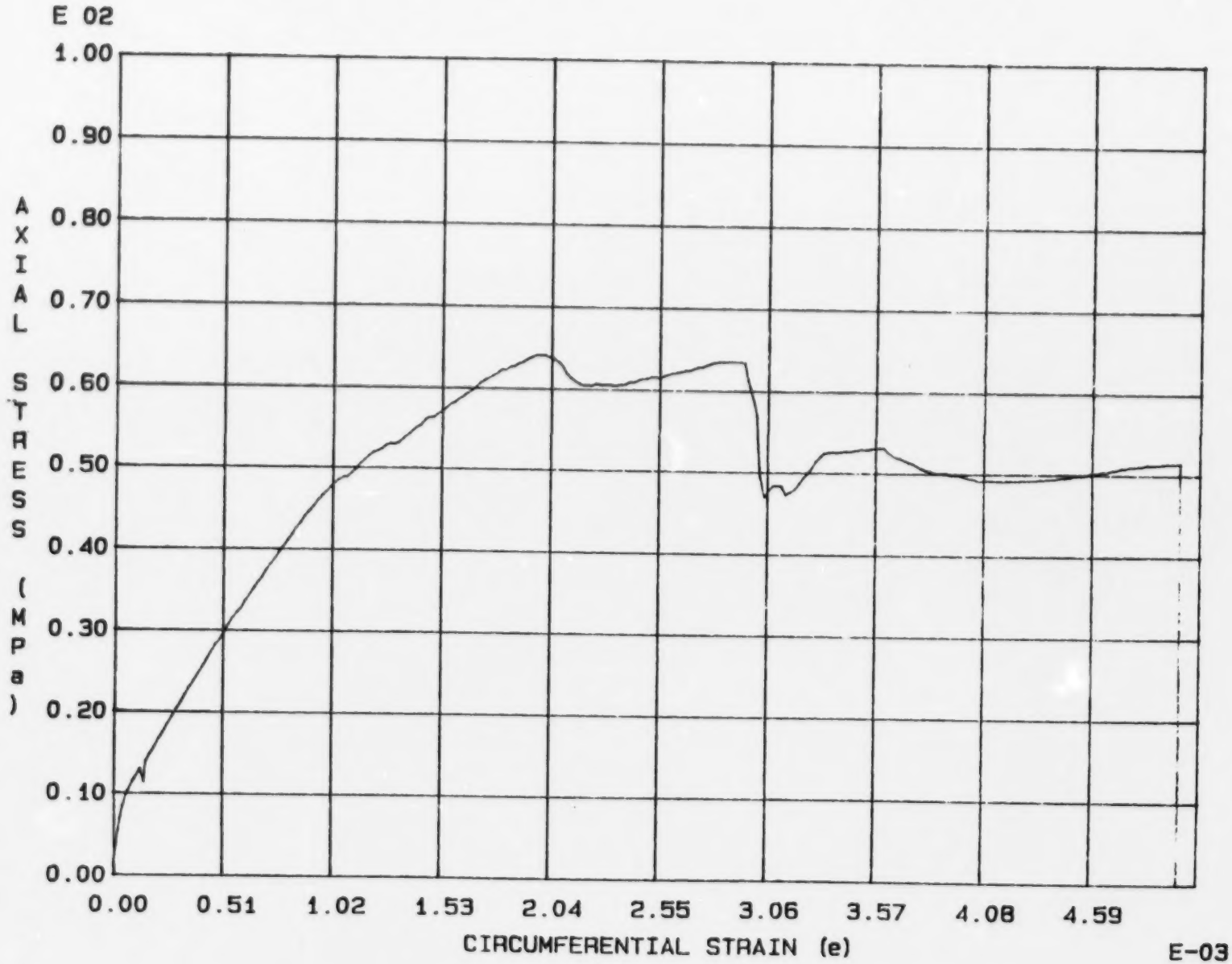


Fig. B-64 E114U

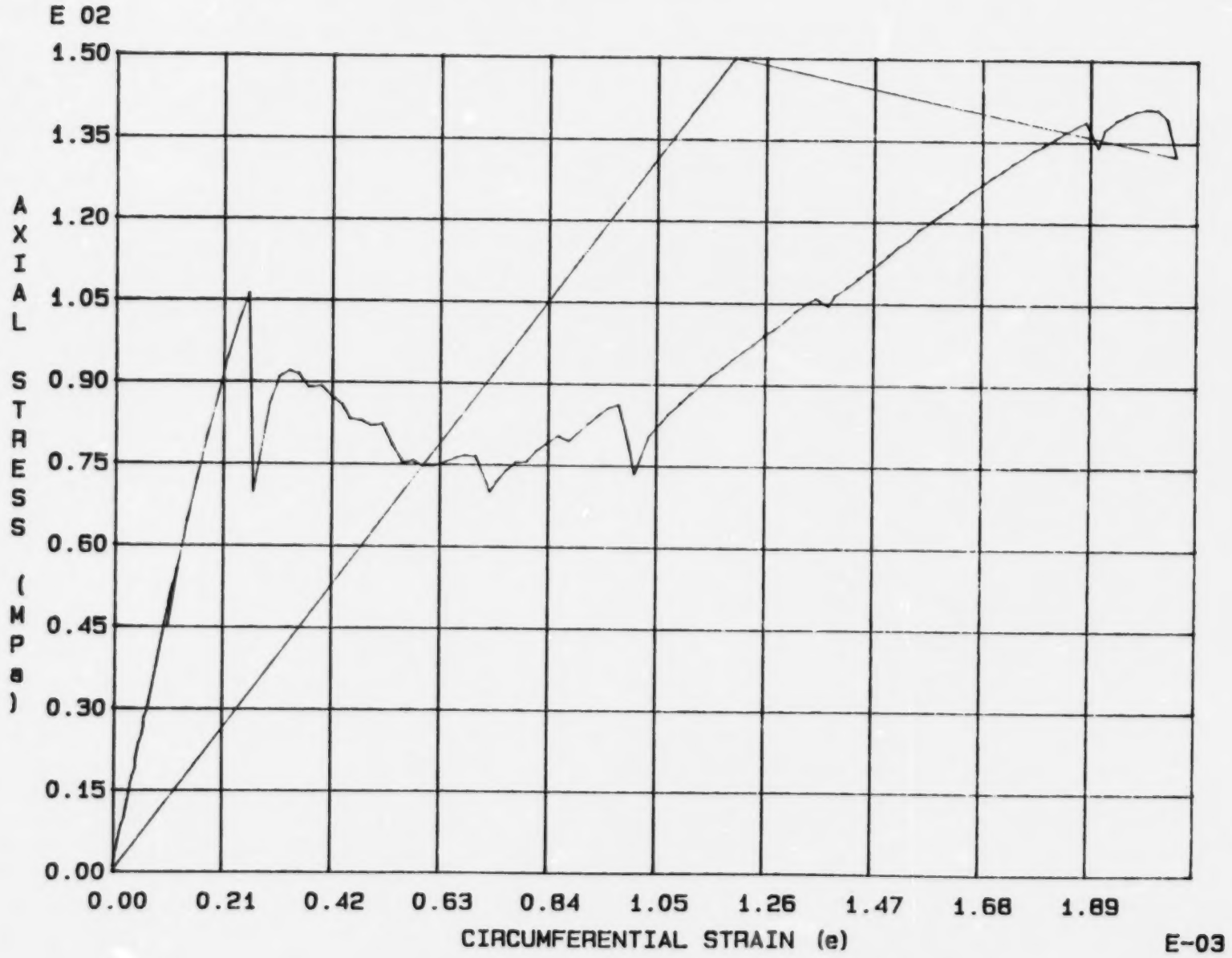


Fig. B-65 E115U

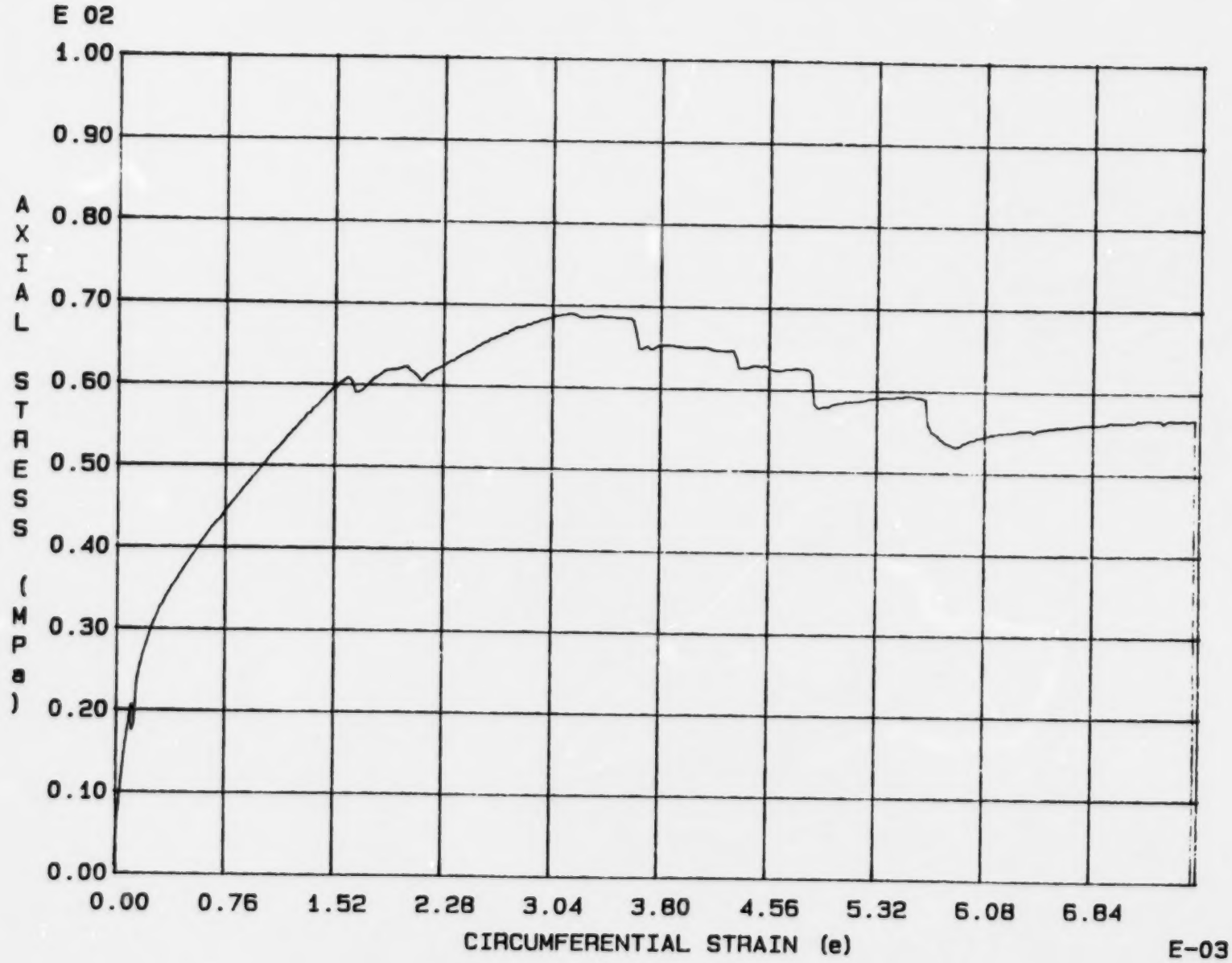


Fig. B-66 E116U

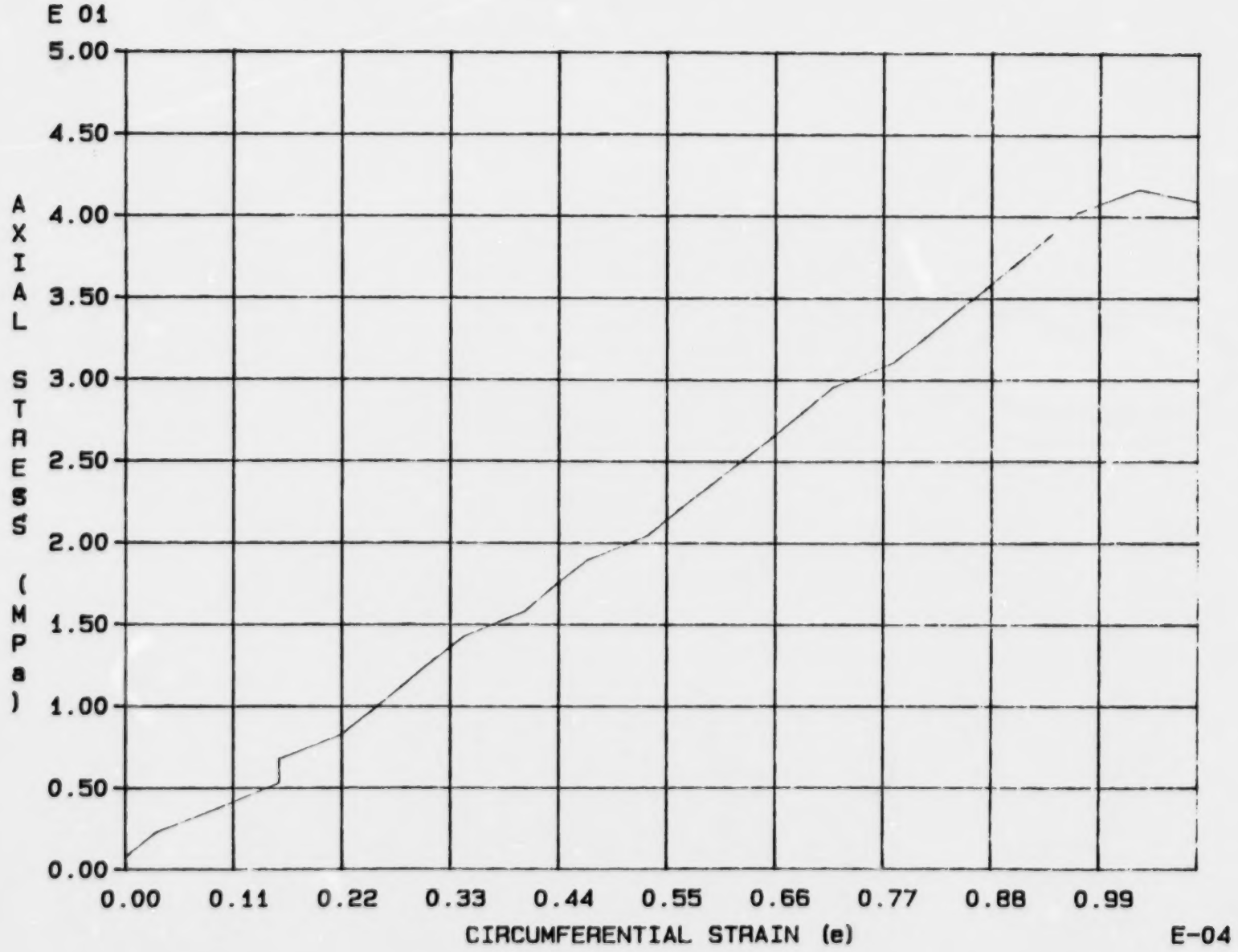


Fig. B-67 E117U

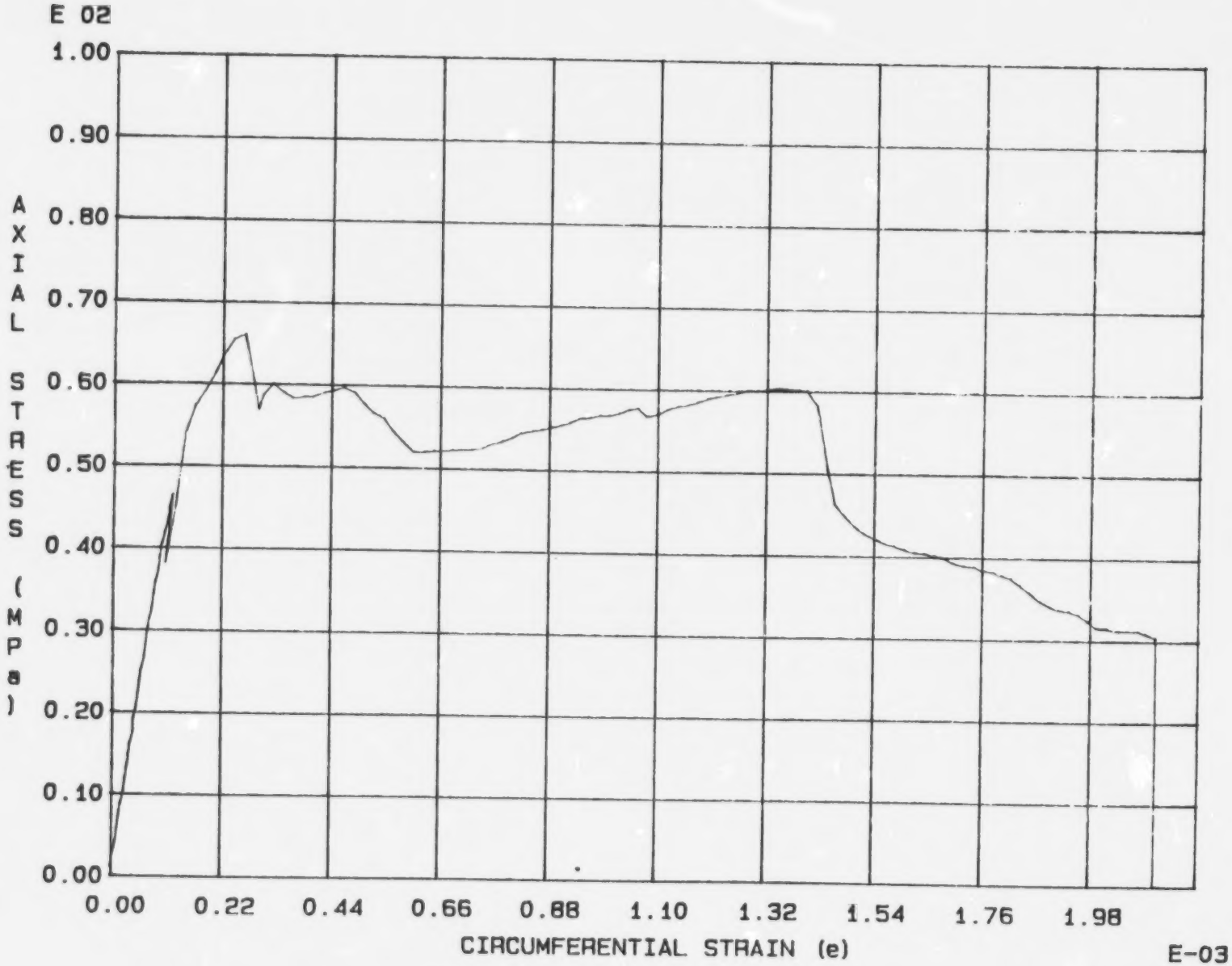


Fig. B-68 E118U

APPENDIX C

STRESS-STRAIN CURVES OF UNIAXIAL TESTS USING AXIAL STRAIN GAUGES

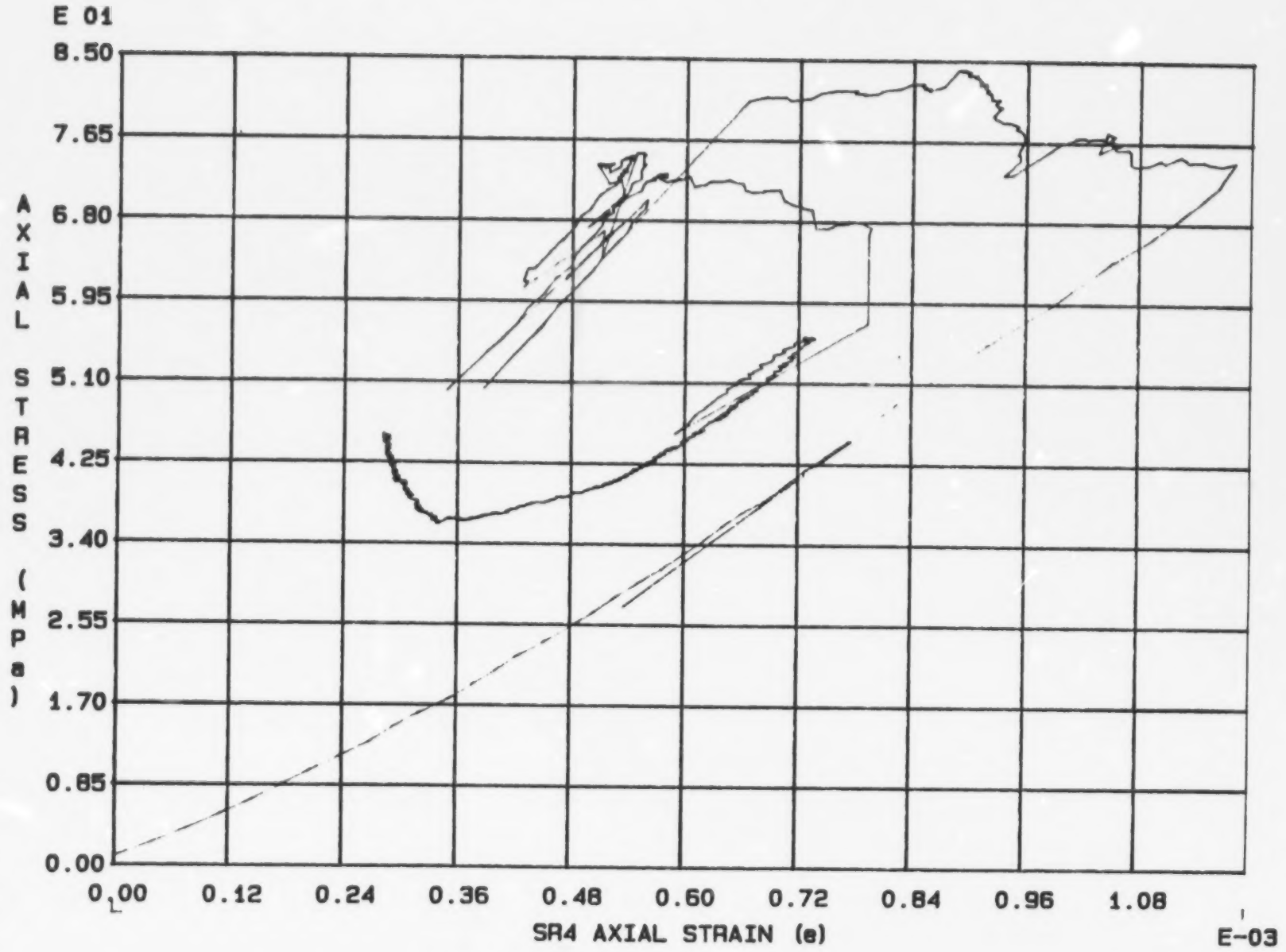

E 01
8.50
7.65
6.80
5.95
5.10
4.25
3.40
2.55
1.70
0.85
0.00
AXIAL STRESS (MPa)
0.00
0.12
0.24
0.36
0.48
0.60
0.72
0.84
0.96
1.08
SR4 AXIAL STRAIN (e)
E-03

Fig. C-1 E1U

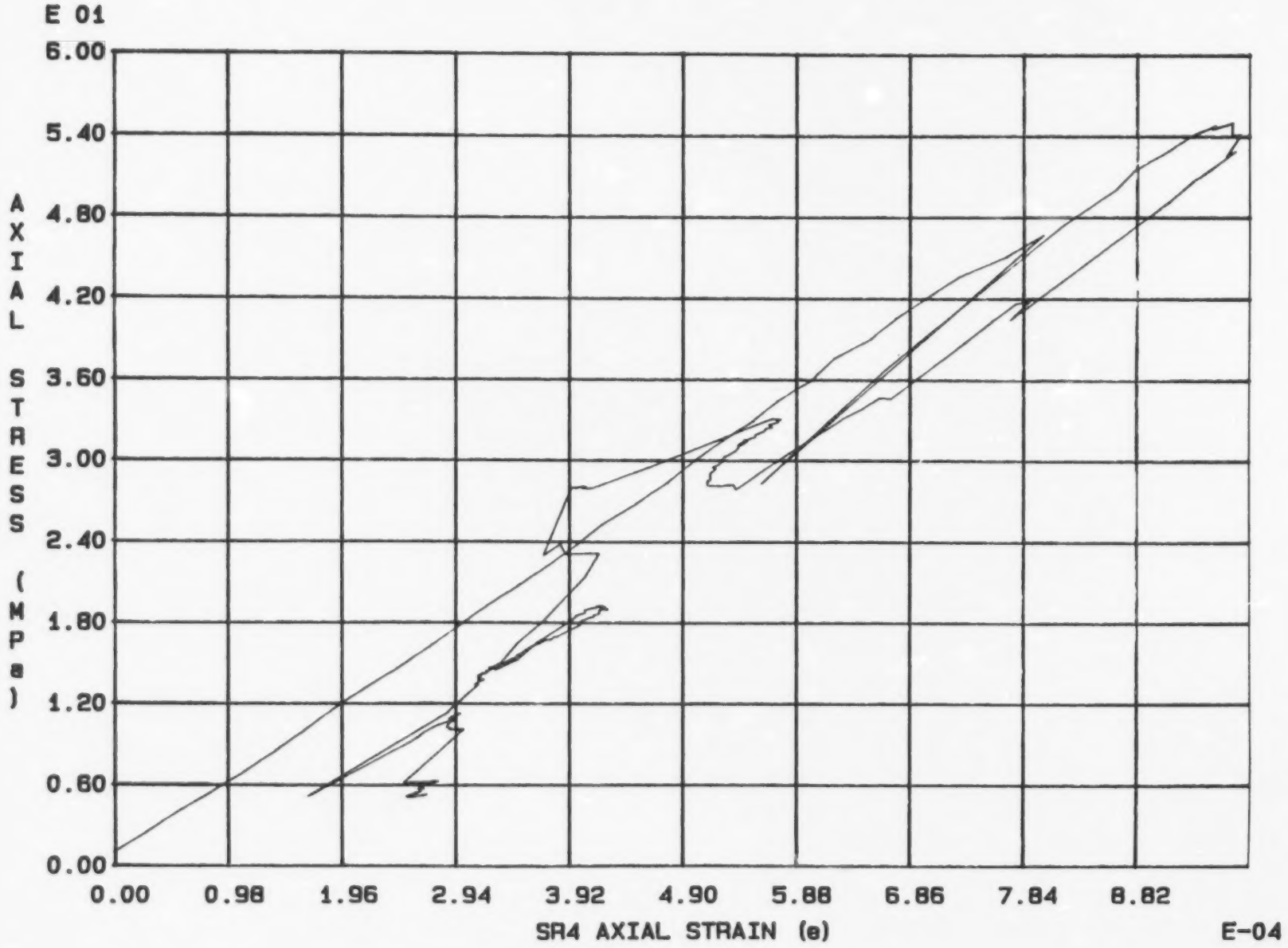

E 01
6.00
5.40
4.80
4.20
3.60
3.00
2.40
1.80
1.20
0.60
0.00
AXIAL STRESS (MPa)
0.00
0.98
1.96
2.94
3.92
4.90
5.88
6.86
7.84
8.82
SR4 AXIAL STRAIN (e)
E-04

Fig. C-2 E3U

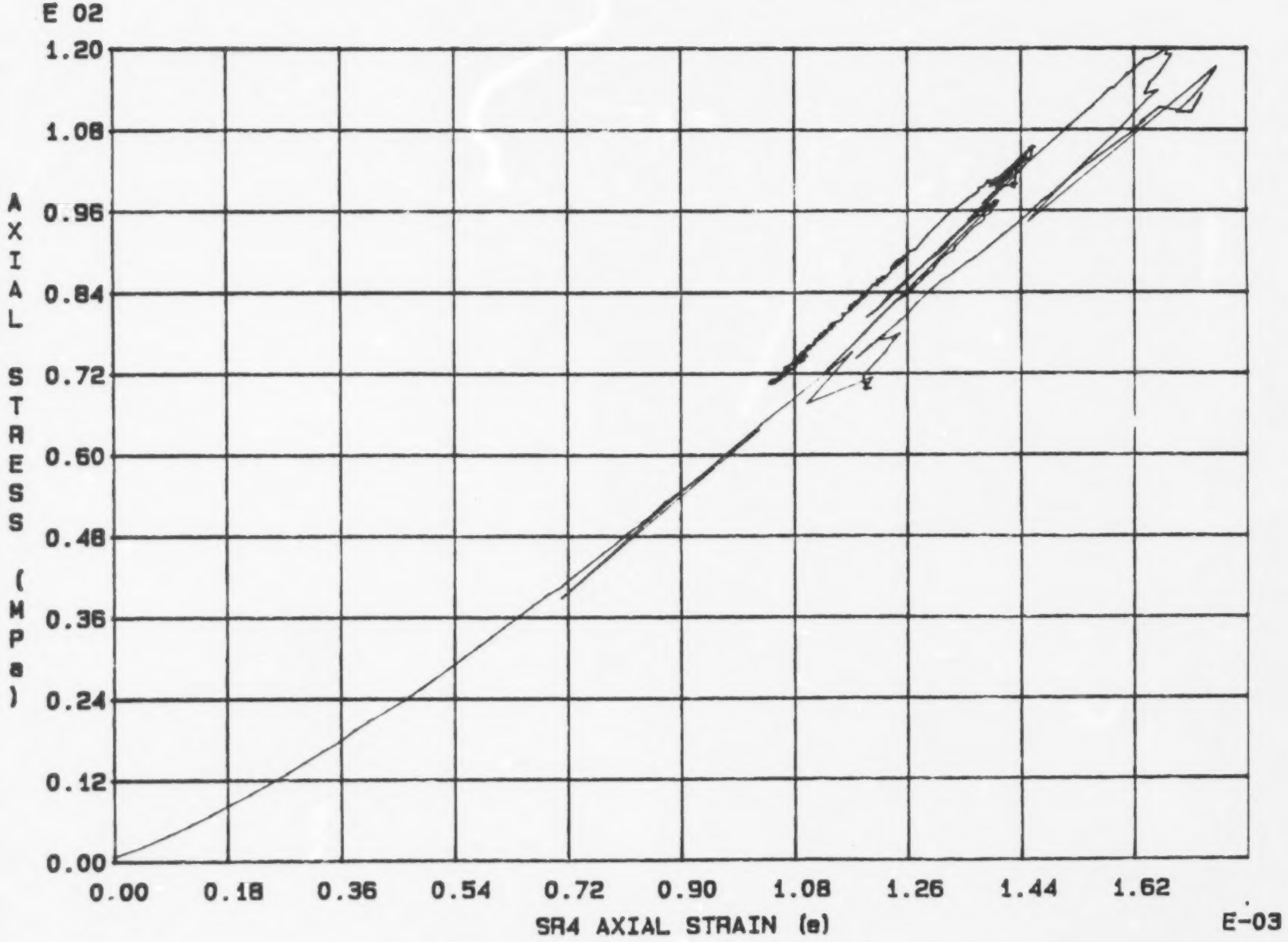

E 02
1.20
1.08
0.96
0.84
0.72
0.60
0.48
0.36
0.24
0.12
0.00
AXIAL STRESS (MPa)
0.00
0.18
0.36
0.54
0.72
0.90
1.08
1.26
1.44
1.62
SR4 AXIAL STRAIN (e)
E-03

Fig. C-3 E5U

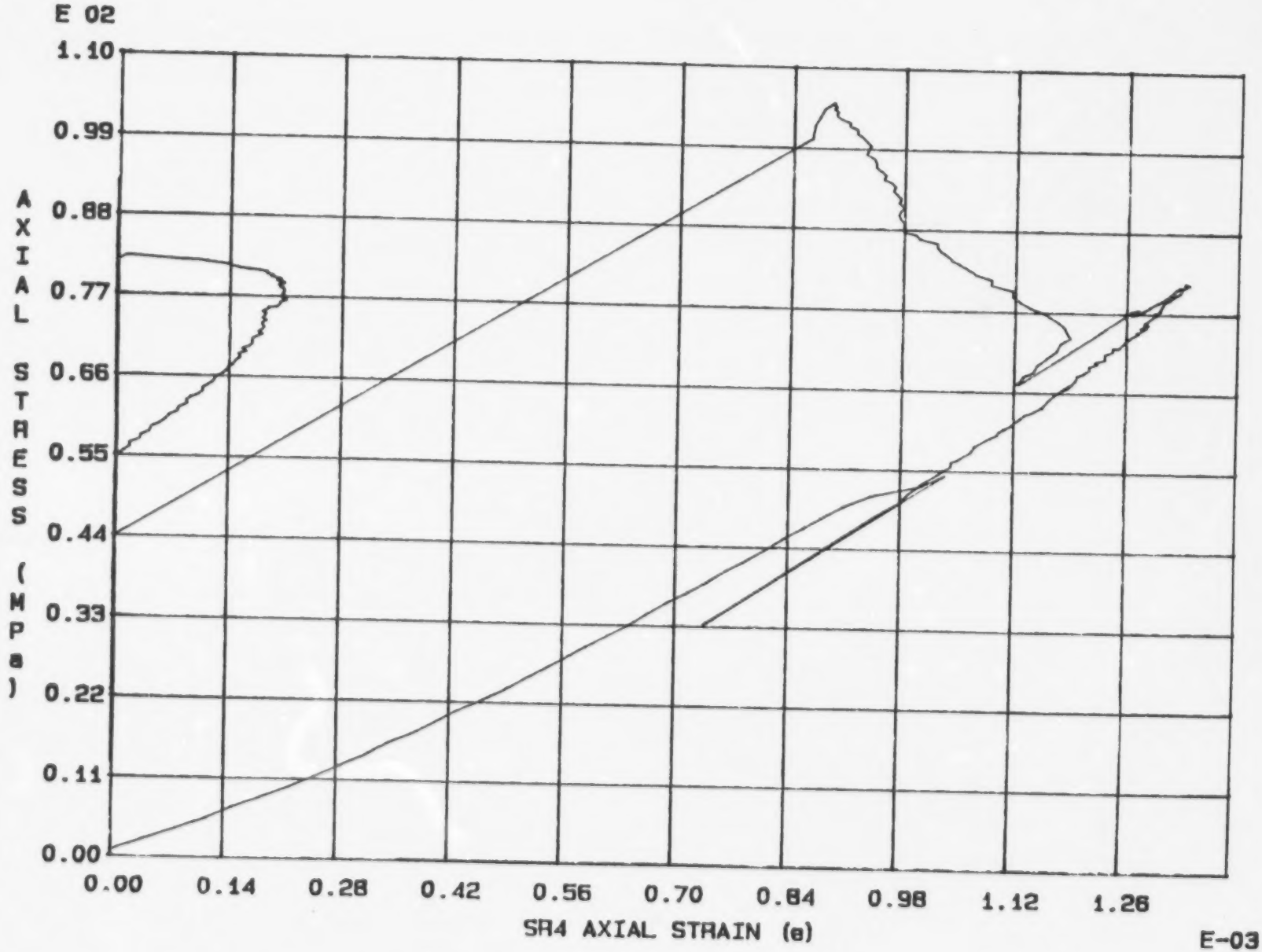

E 02
1.10
0.99
0.88
0.77
0.66
0.55
0.44
0.33
0.22
0.11
0.00
AXIAL STRESS (MPa)
0.00
0.14
0.28
0.42
0.56
0.70
0.84
0.98
1.12
1.26
SR4 AXIAL STRAIN (e)
E-03

Fig. C-4 E7U

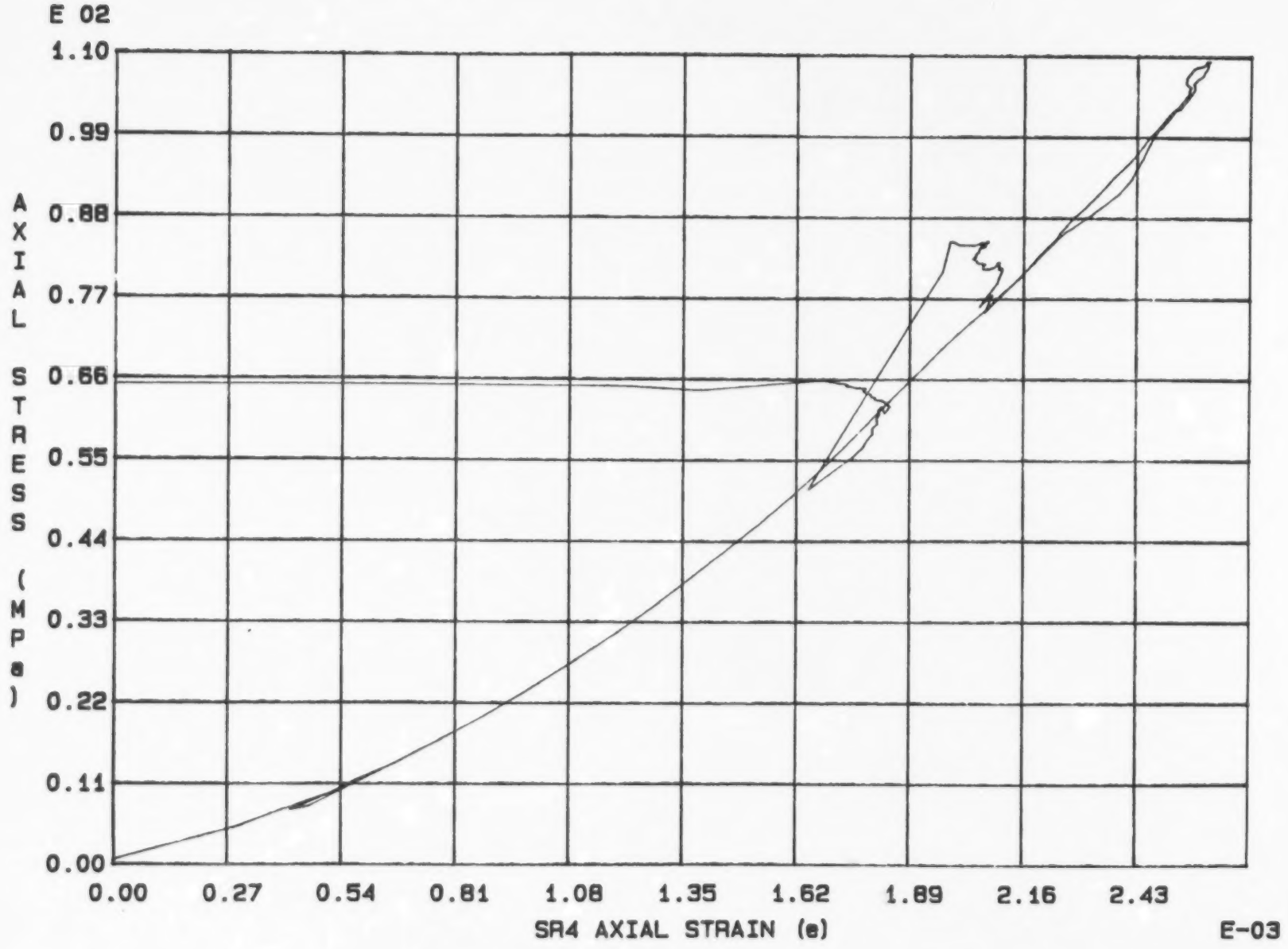

E 02
1.10
0.99
0.88
0.77
0.66
0.55
0.44
0.33
0.22
0.11
0.00
AXIAL STRESS (MPa)
0.00
0.27
0.54
0.81
1.08
1.35
1.62
1.89
2.16
2.43
SR4 AXIAL STRAIN (e)
E-03

Fig. C-5 E9UA

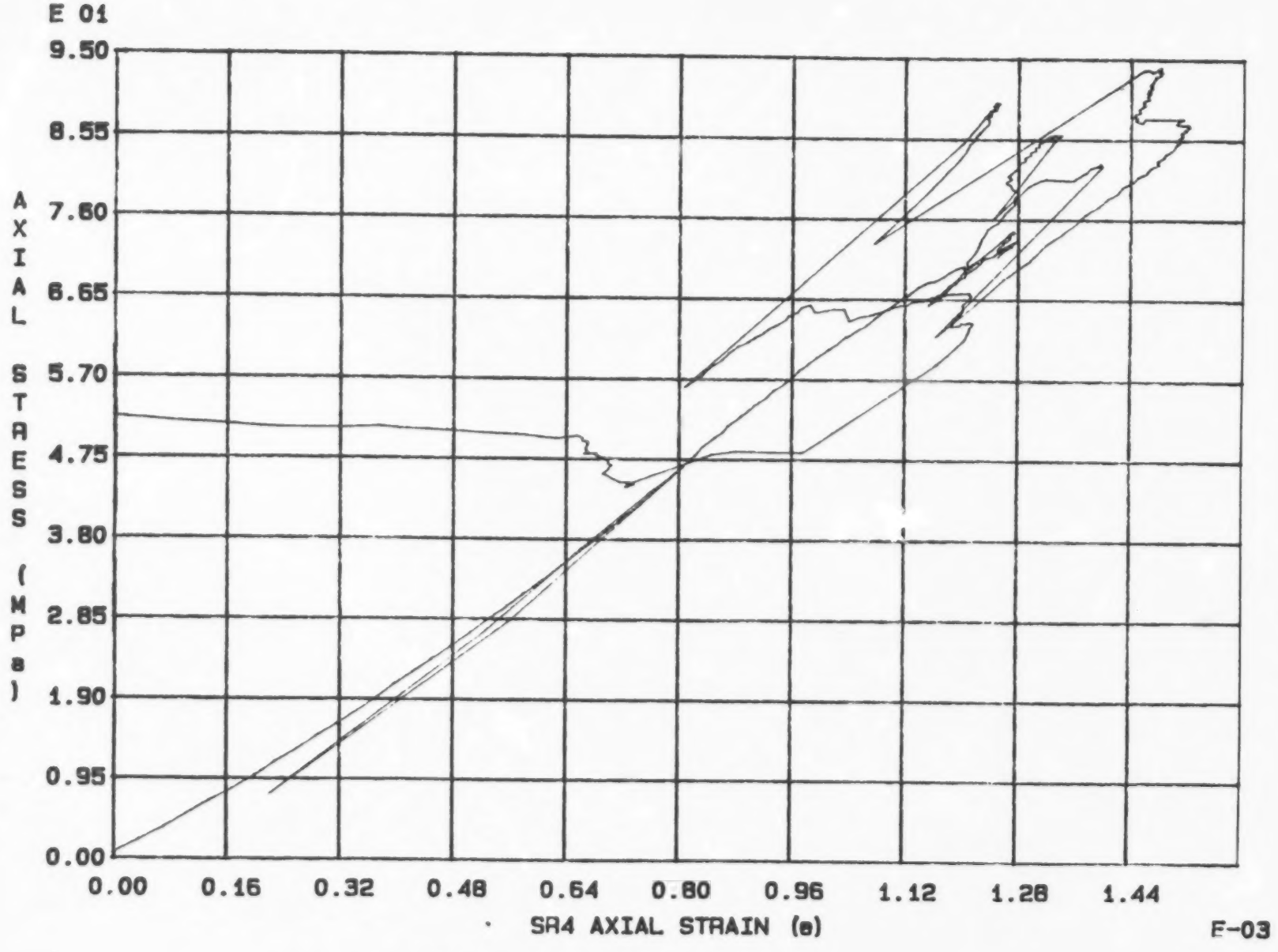

E 01
9.50
8.55
7.60
6.65
5.70
4.75
3.80
2.85
1.90
0.95
0.00
AXIAL STRESS (MPa)
0.00
0.16
0.32
0.48
0.64
0.80
0.96
1.12
1.28
1.44
SR4 AXIAL STRAIN (e)
E-03

Fig. C-6 E11U

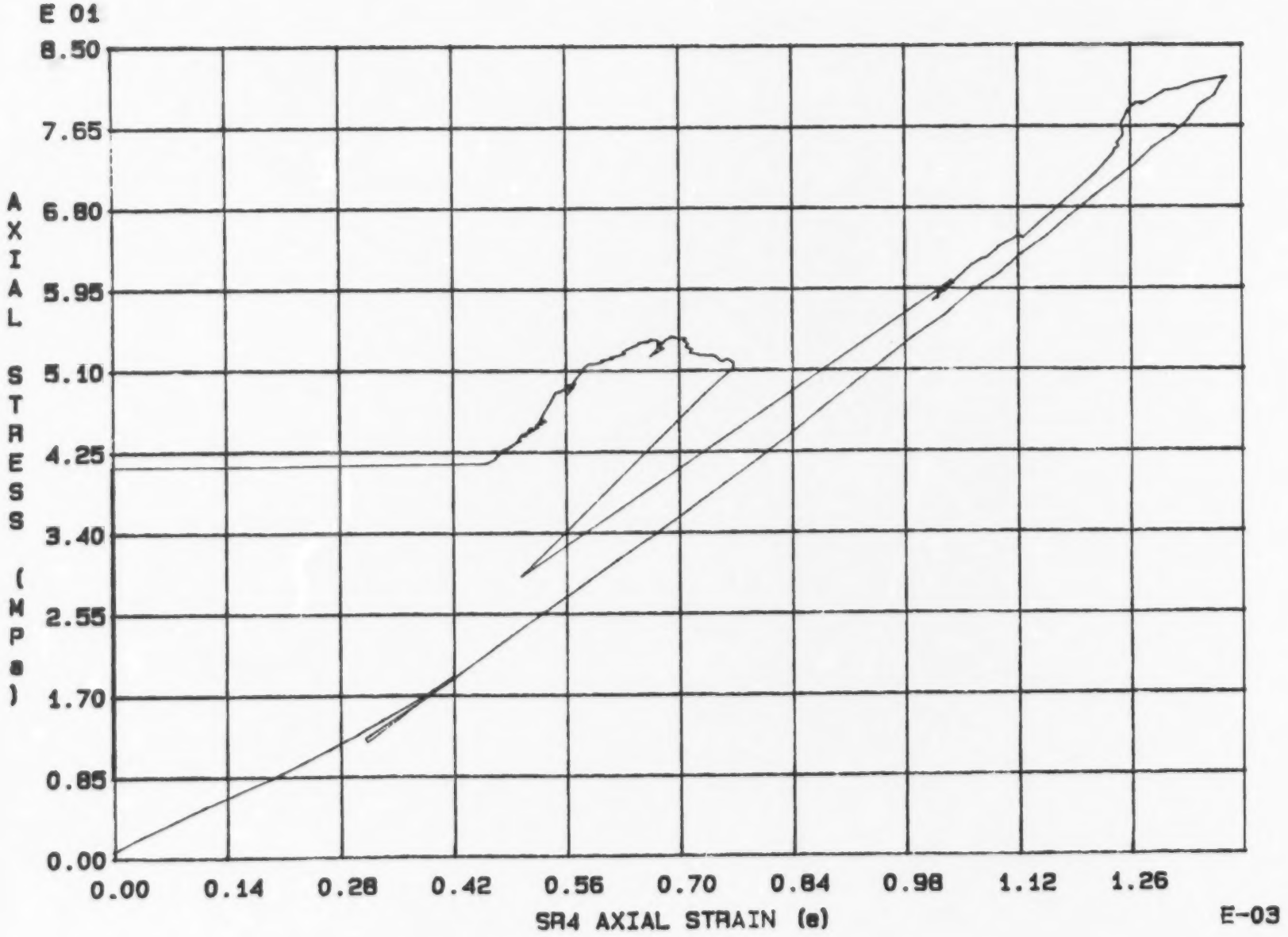

E 01
8.50
7.65
6.80
5.95
5.10
4.25
3.40
2.55
1.70
0.85
0.00
AXIAL STRESS (MPa)
0.00
0.14
0.28
0.42
0.56
0.70
0.84
0.98
1.12
1.26
SR4 AXIAL STRAIN (e)
E-03

Fig. C-7 E13U

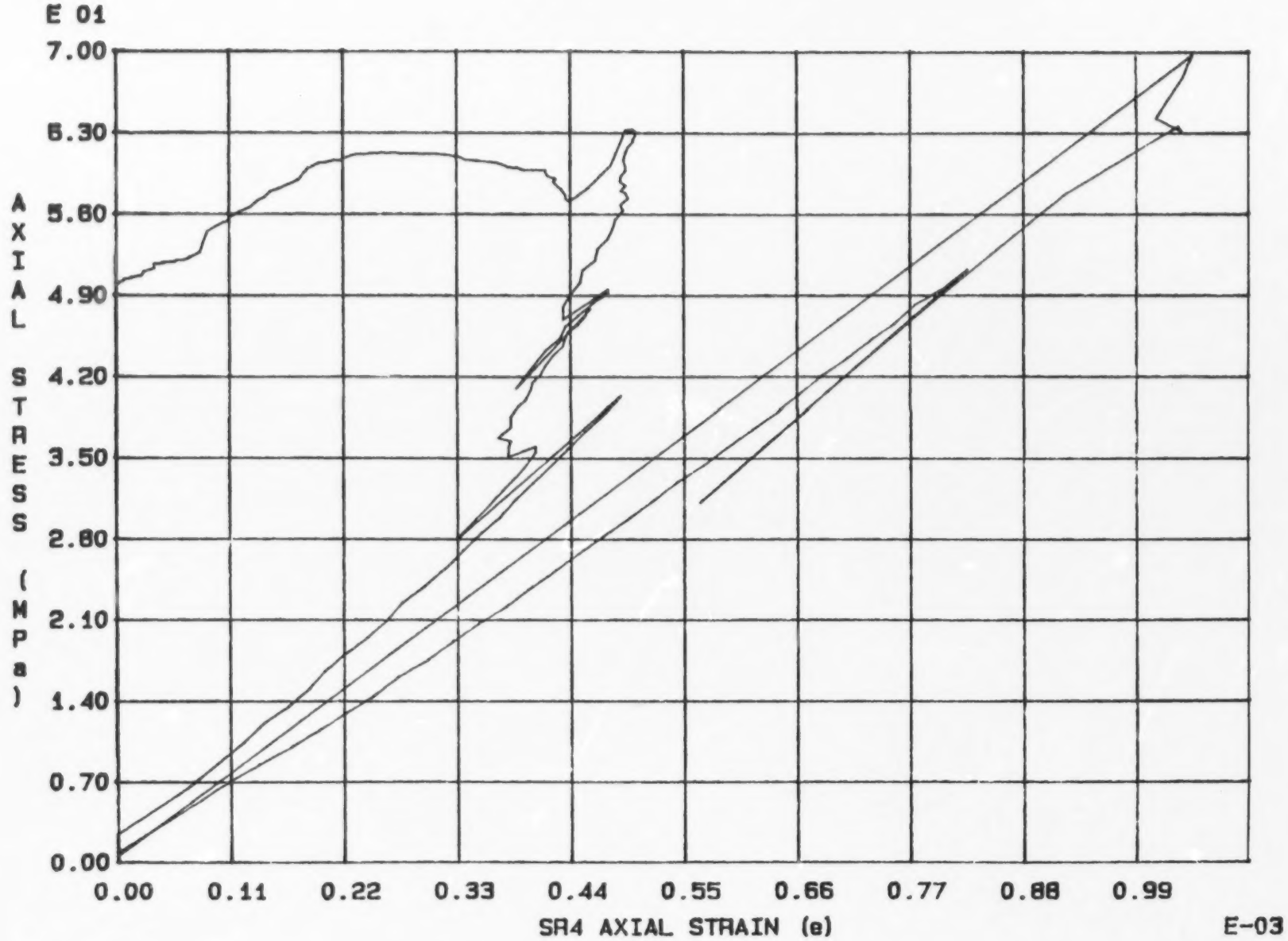

E 01
7.00
6.30
5.60
4.90
4.20
3.50
2.80
2.10
1.40
0.70
0.00
AXIAL STRESS (MPa)
0.00
0.11
0.22
0.33
0.44
0.55
0.66
0.77
0.88
0.99
SR4 AXIAL STRAIN (e)
E-03

Fig. C-8 E15U

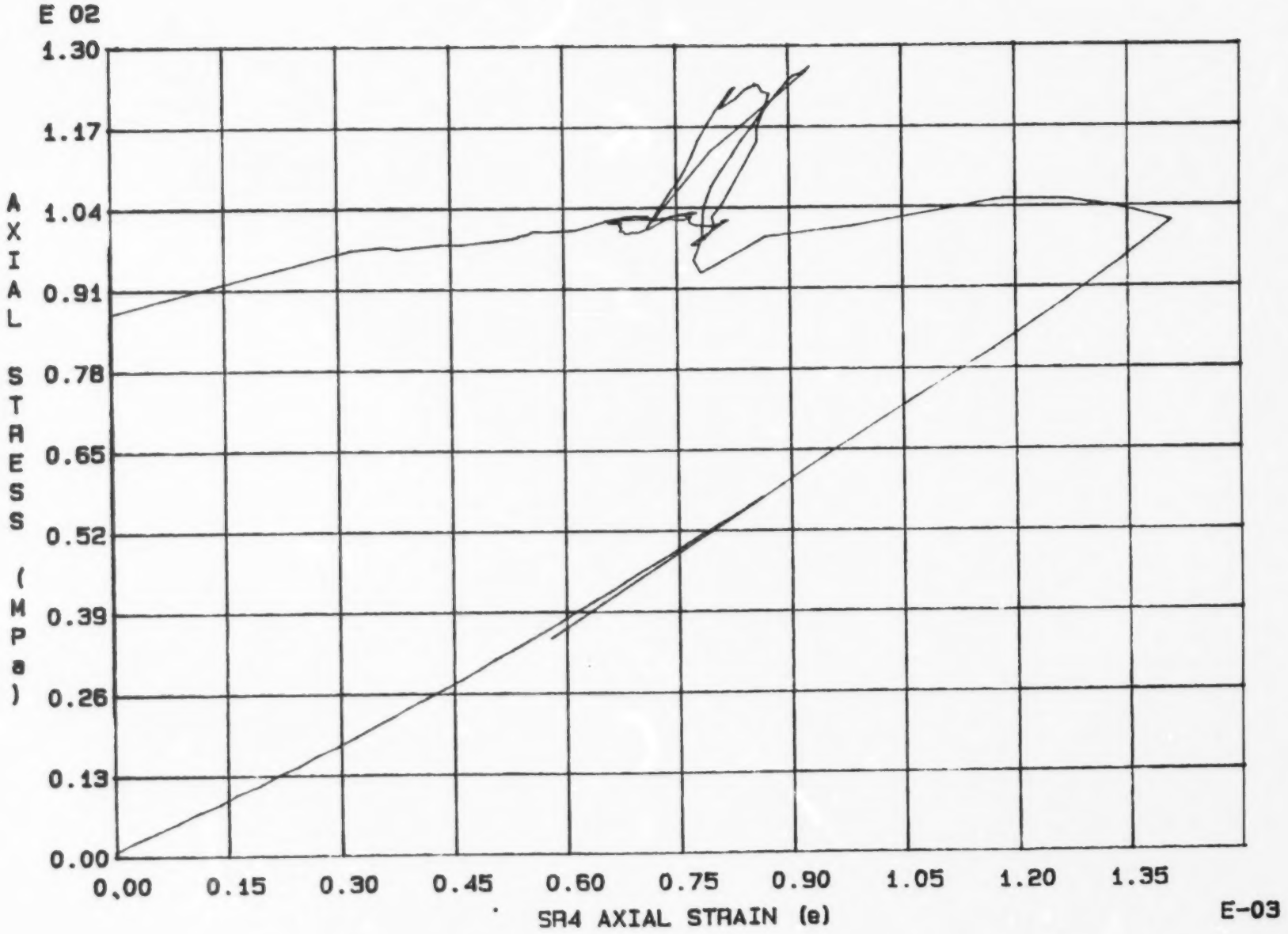

E 02
1.30
1.17
1.04
0.91
0.78
0.65
0.52
0.39
0.26
0.13
0.00
AXIAL STRESS (MPa)
0.00
0.15
0.30
0.45
0.60
0.75
0.90
1.05
1.20
1.35
SR4 AXIAL STRAIN (e)
E-03

Fig. C-9 E17U

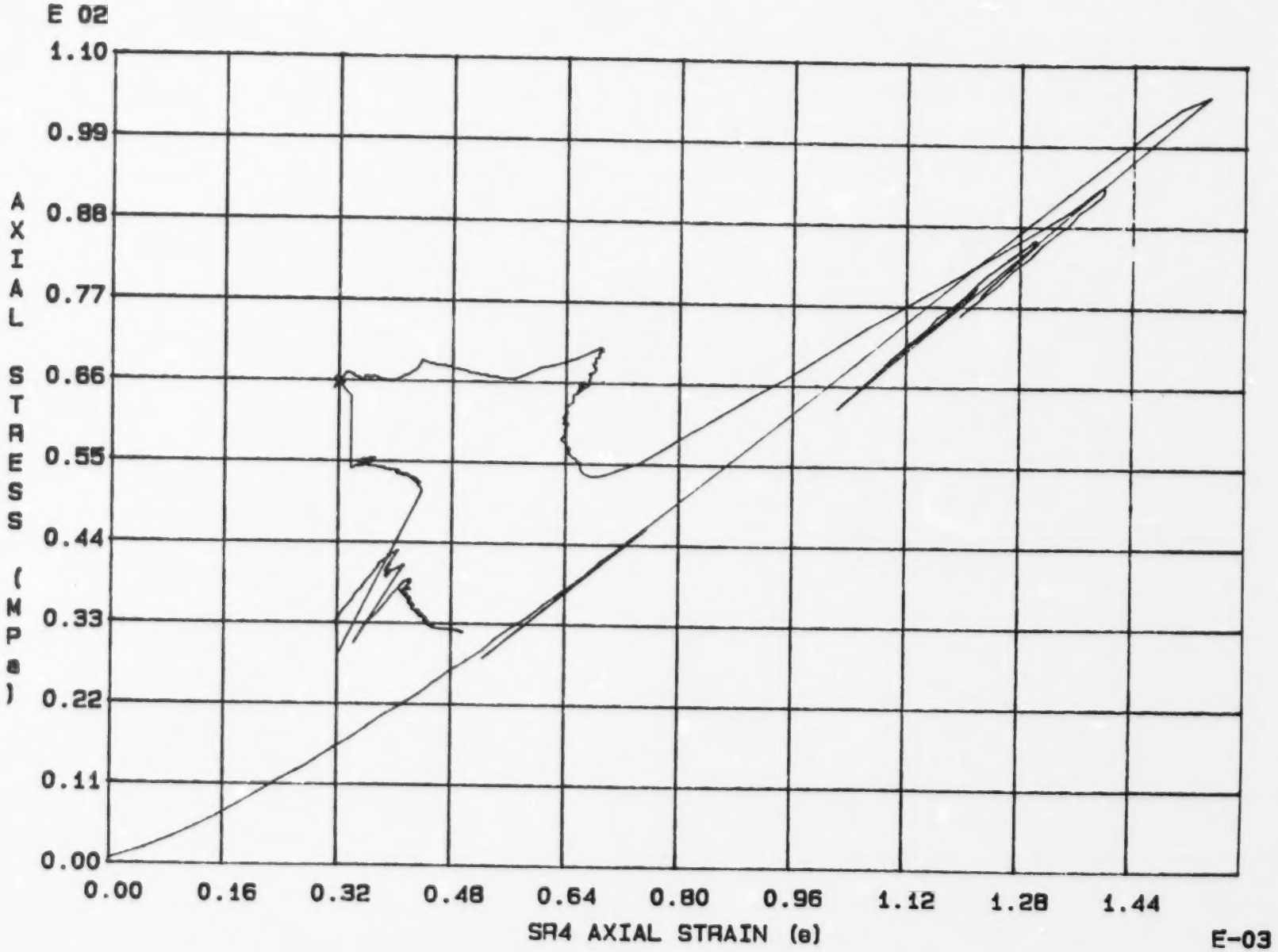

E 02
1.10
0.99
0.88
0.77
0.66
0.55
0.44
0.33
0.22
0.11
0.00
AXIAL STRESS (MPa)
0.00
0.16
0.32
0.48
0.64
0.80
0.96
1.12
1.28
1.44
SR4 AXIAL STRAIN (e)
E-03

Fig. C-10 E19U

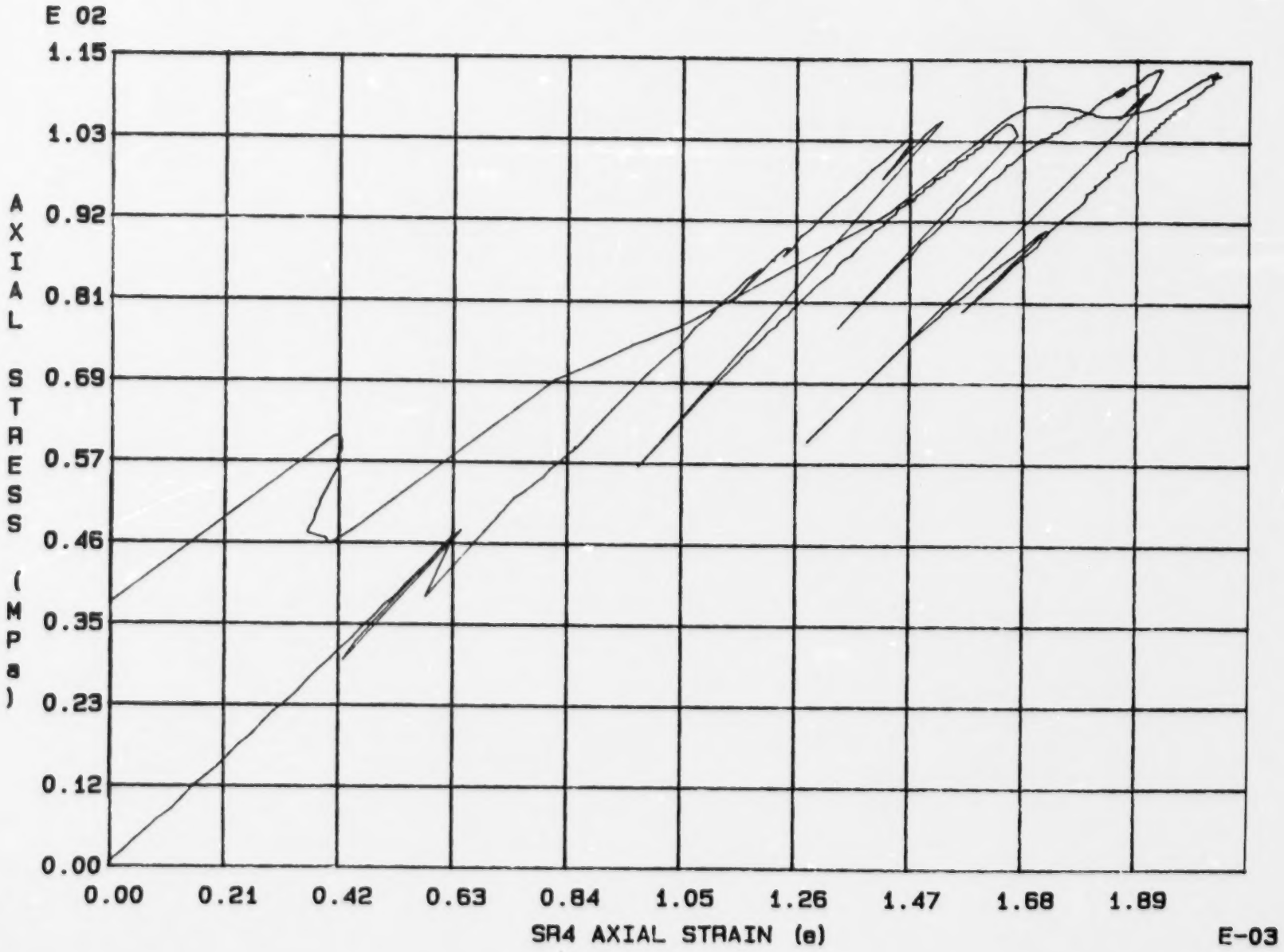

E 02
1.15
1.03
0.92
0.81
0.69
0.57
0.46
0.35
0.23
0.12
0.00
AXIAL STRESS (MPa)
0.00
0.21
0.42
0.63
0.84
1.05
1.26
1.47
1.68
1.89
SR4 AXIAL STRAIN (e)
E-03

Fig. C-11 E21U

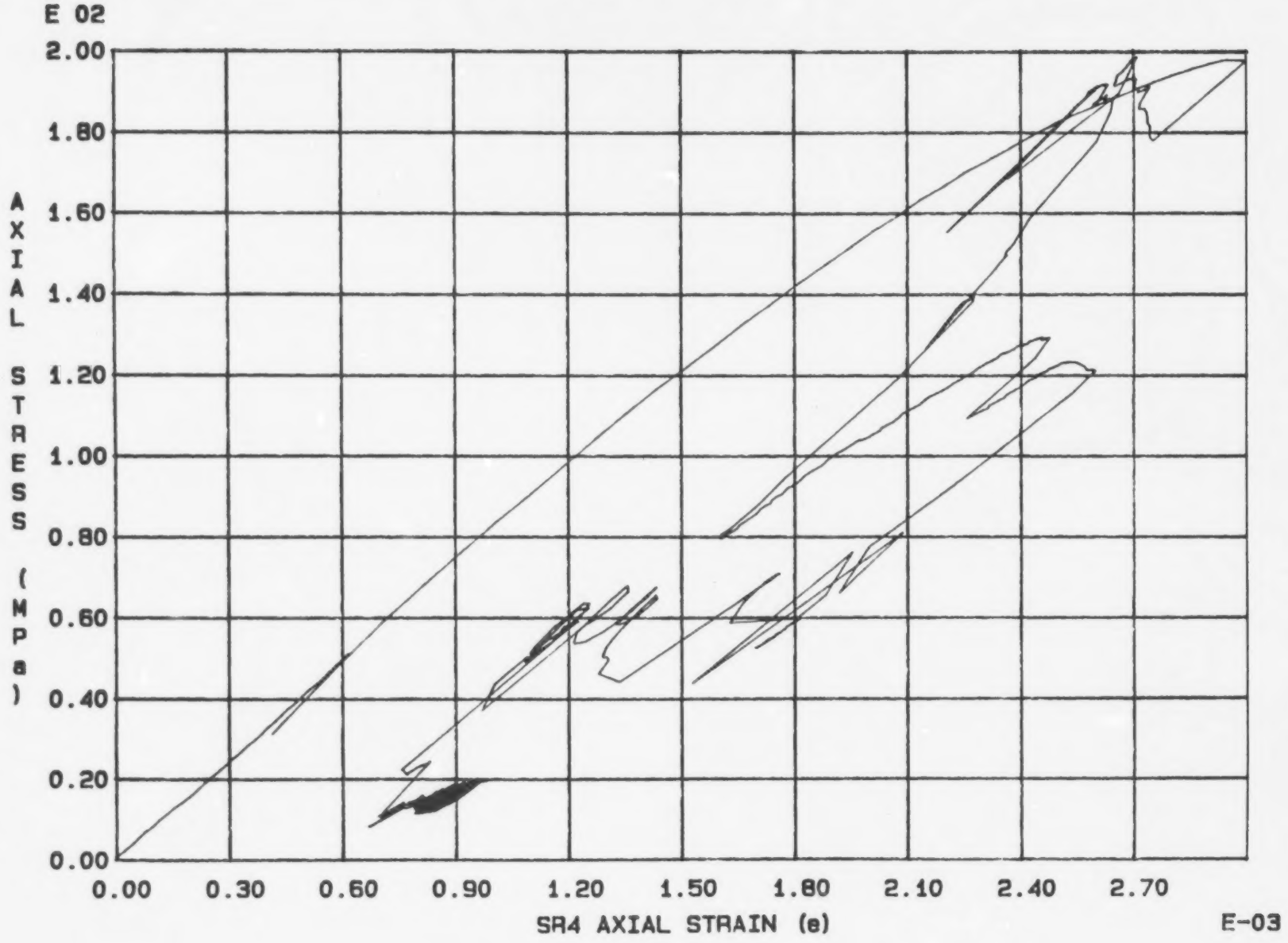

E 02
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
AXIAL STRESS (MPa)
0.00
0.30
0.60
0.90
1.20
1.50
1.80
2.10
2.40
2.70
SR4 AXIAL STRAIN (e)
E-03

Fig. C-12 E23U

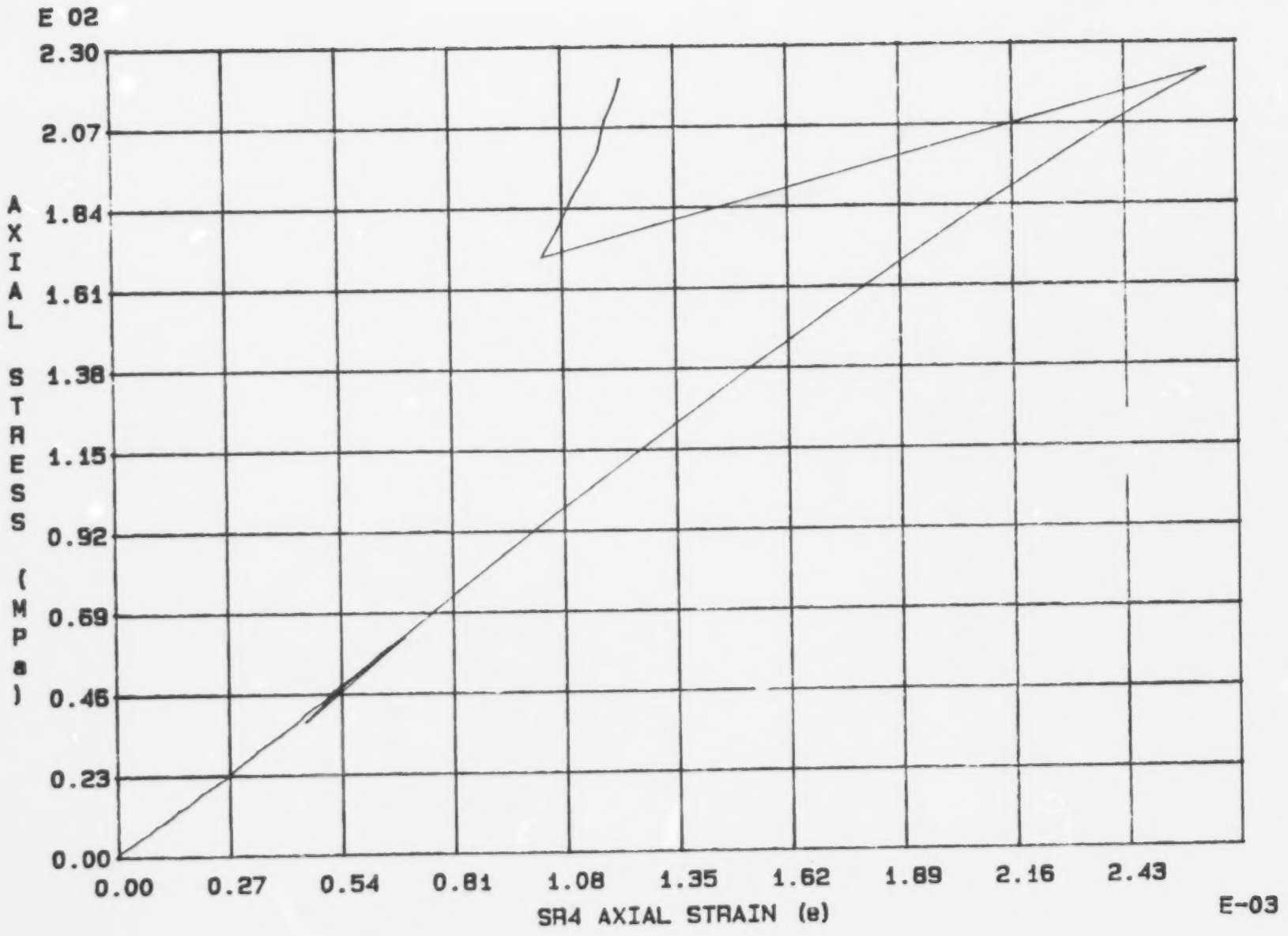

E 02
2.30
2.07
1.84
1.61
1.38
1.15
0.92
0.69
0.46
0.23
0.00
AXIAL STRESS (MPa)
0.00
0.27
0.54
0.81
1.08
1.35
1.62
1.89
2.16
2.43
E-03
SR4 AXIAL STRAIN (e)

Fig. C-13 E25U

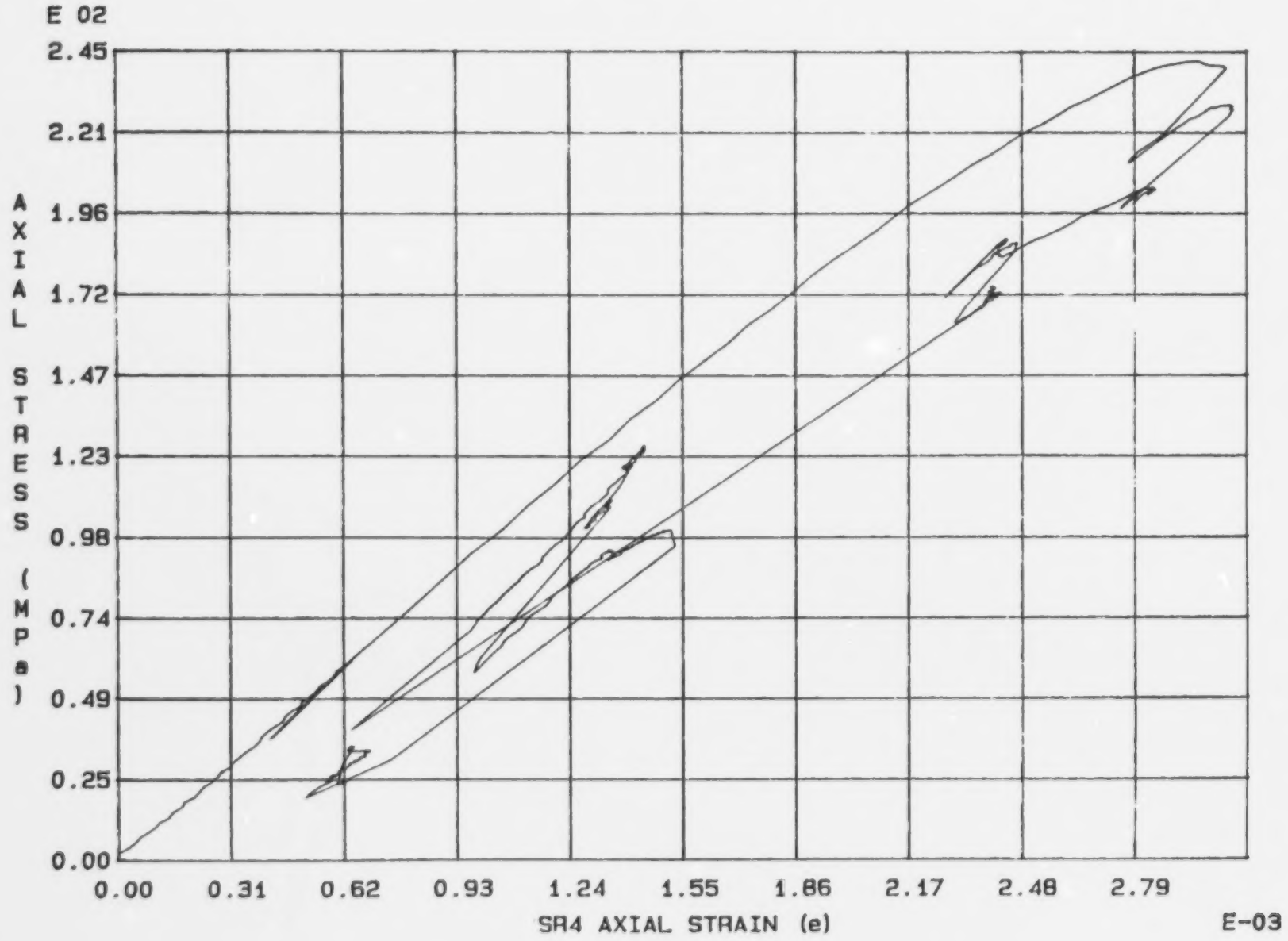

E 02
2.45
2.21
1.96
1.72
1.47
1.23
0.98
0.74
0.49
0.25
0.00
AXIAL STRESS (MPa)
0.00
0.31
0.62
0.93
1.24
1.55
1.86
2.17
2.48
2.79
SR4 AXIAL STRAIN (e)
E-03

Fig. C-14 E27U

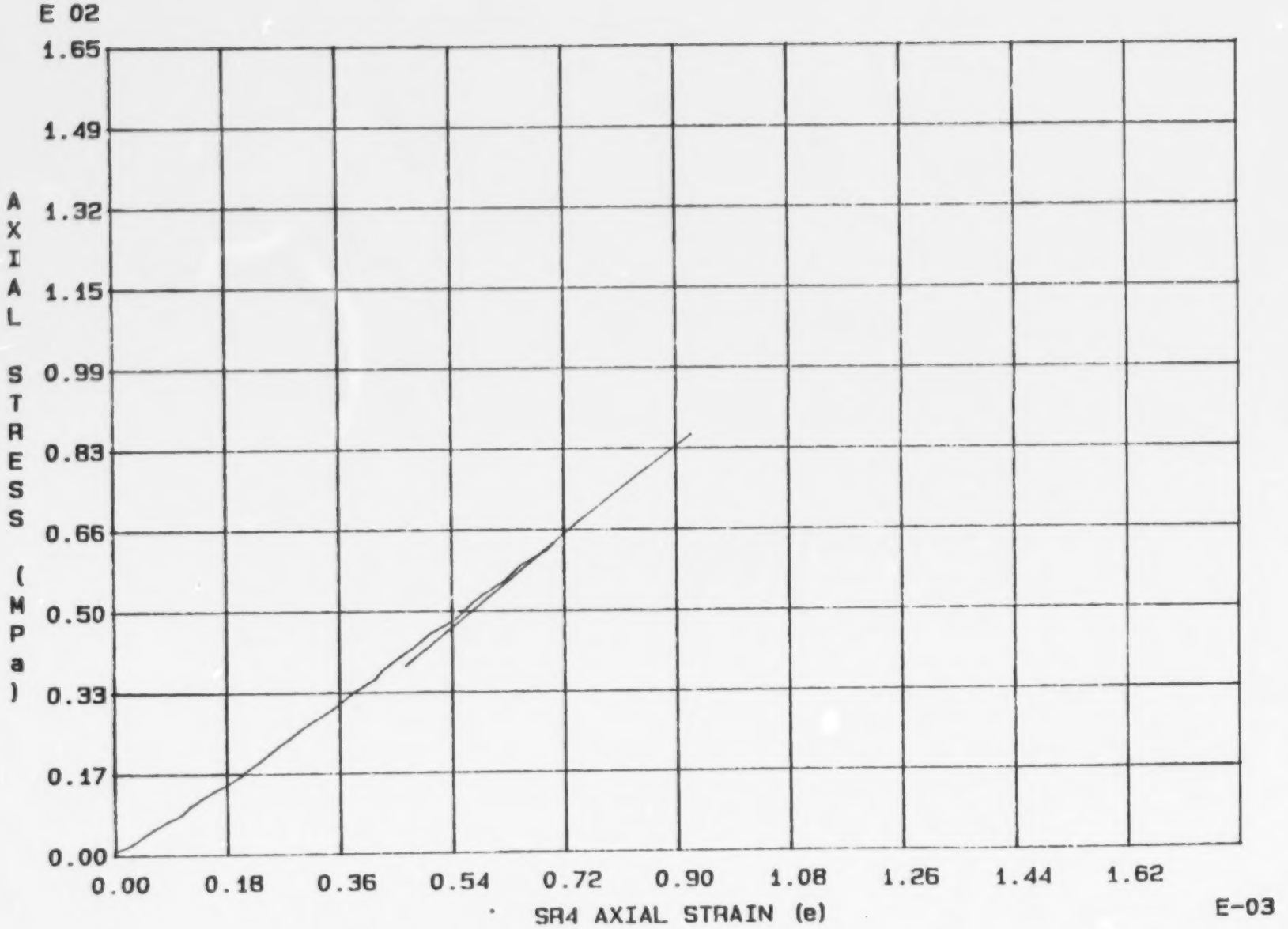

E 02
1.65
1.49
1.32
1.15
0.99
0.83
0.66
0.50
0.33
0.17
0.00
AXIAL STRESS (MPa)
0.00
0.18
0.36
0.54
0.72
0.90
1.08
1.26
1.44
1.62
SR4 AXIAL STRAIN (e)
E-03

Fig. C-15 E29U

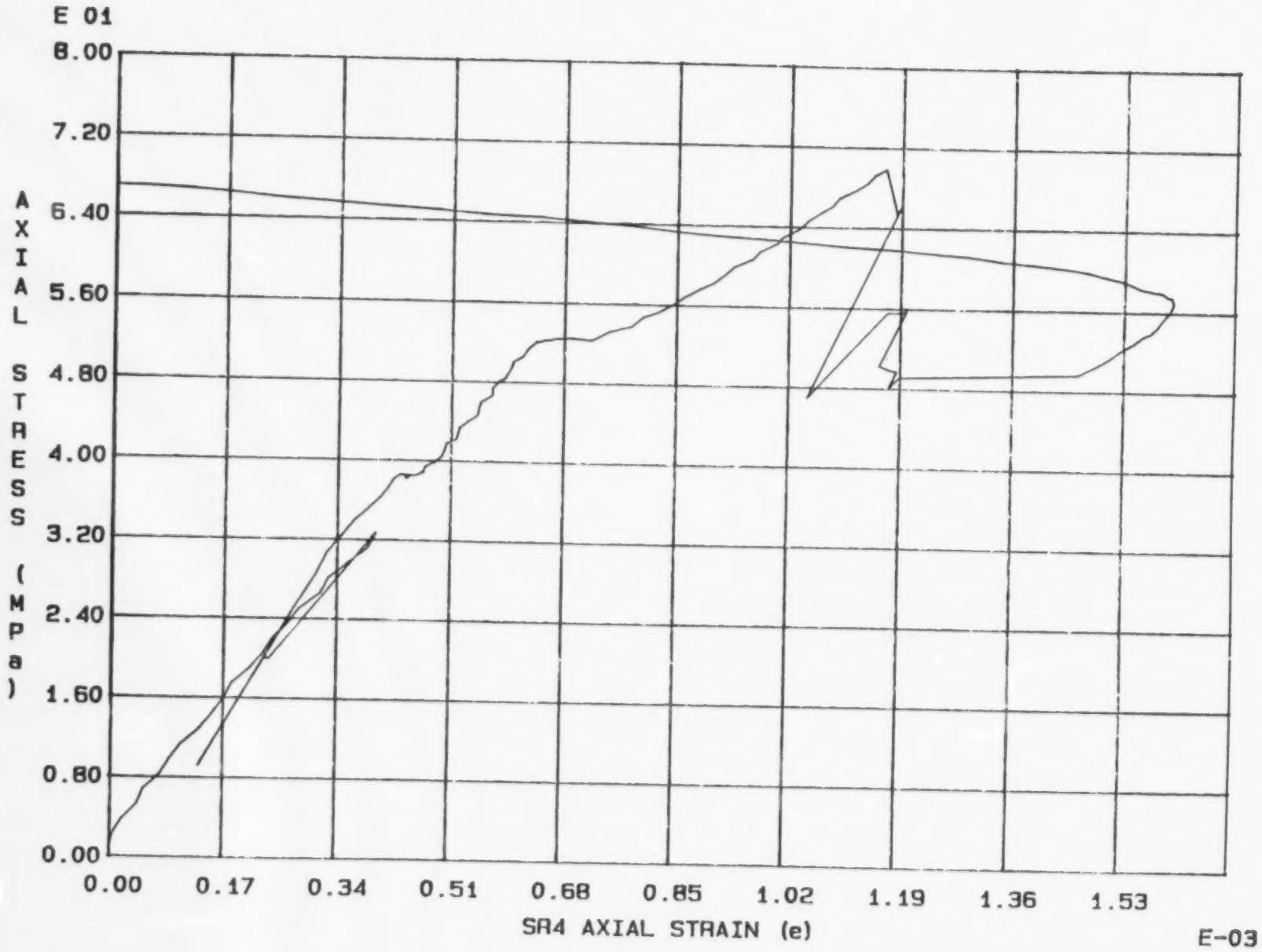

E 01
8.00
7.20
6.40
5.60
4.80
4.00
3.20
2.40
1.60
0.80
0.00
AXIAL STRESS (MPa)
0.00
0.17
0.34
0.51
0.68
0.85
1.02
1.19
1.36
1.53
SR4 AXIAL STRAIN (e)
E-03

Fig. C-16 E31U

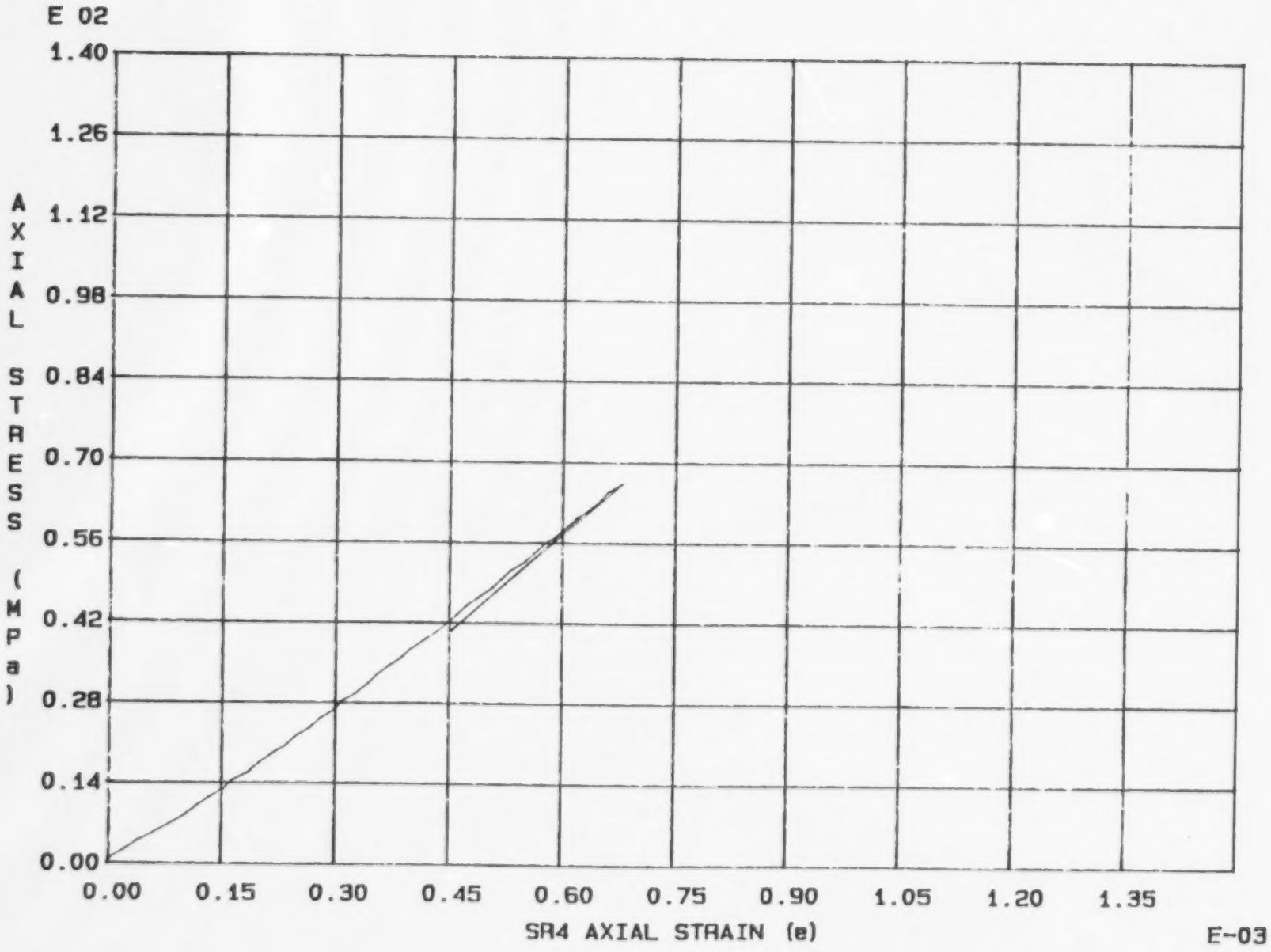

E 02
1.40
1.26
1.12
0.98
0.84
0.70
0.56
0.42
0.28
0.14
0.00
AXIAL STRESS (MPa)
0.00
0.15
0.30
0.45
0.60
0.75
0.90
1.05
1.20
1.35
SR4 AXIAL STRAIN (e)
E-03

Fig. C-17 E33U

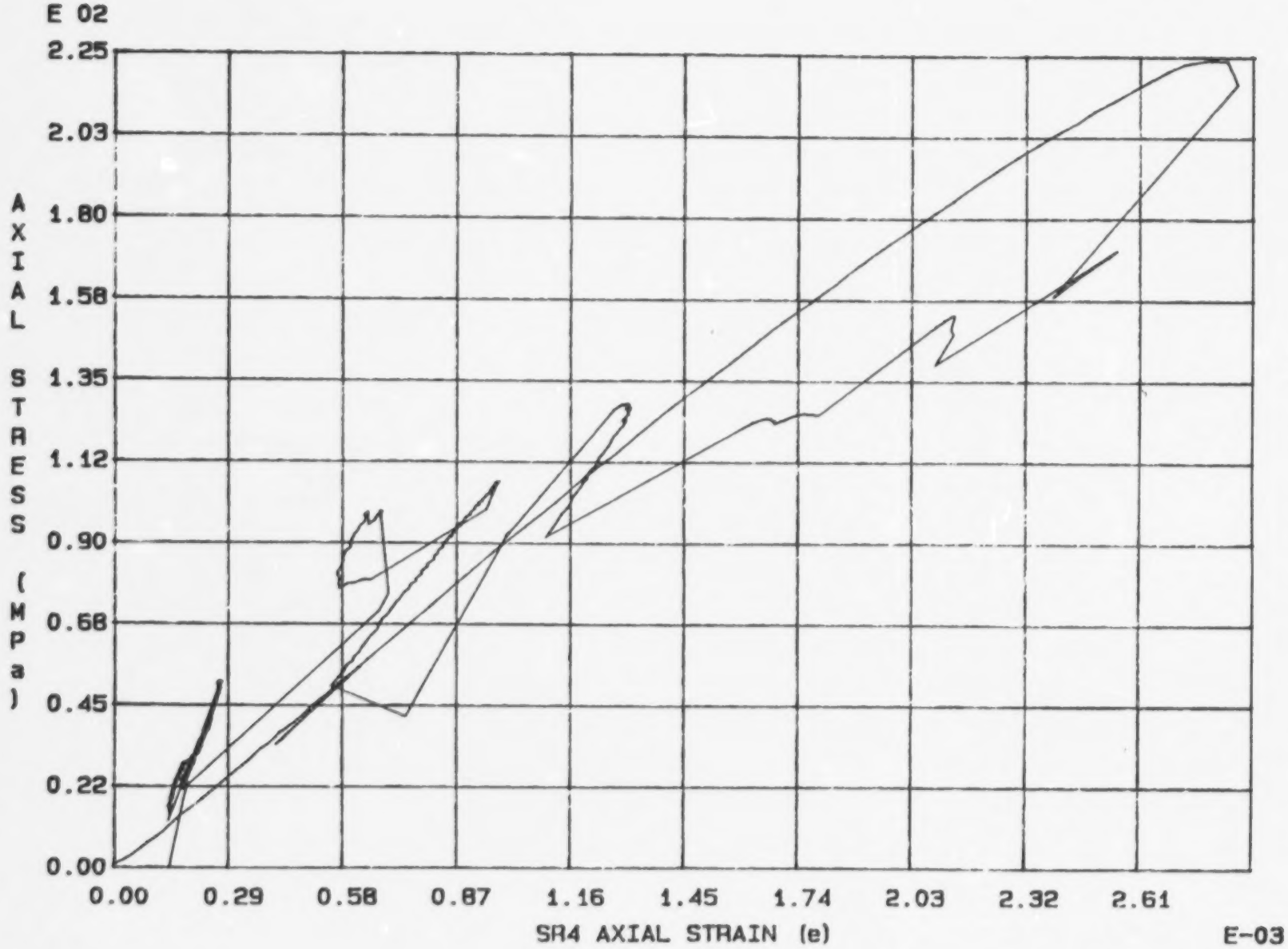

E 02
2.25
2.03
1.80
1.58
1.35
1.12
0.90
0.68
0.45
0.22
0.00
AXIAL STRESS (MPa)
0.00
0.29
0.58
0.87
1.16
1.45
1.74
2.03
2.32
2.61
SR4 AXIAL STRAIN (e)
E-03

Fig. C-18 E35U

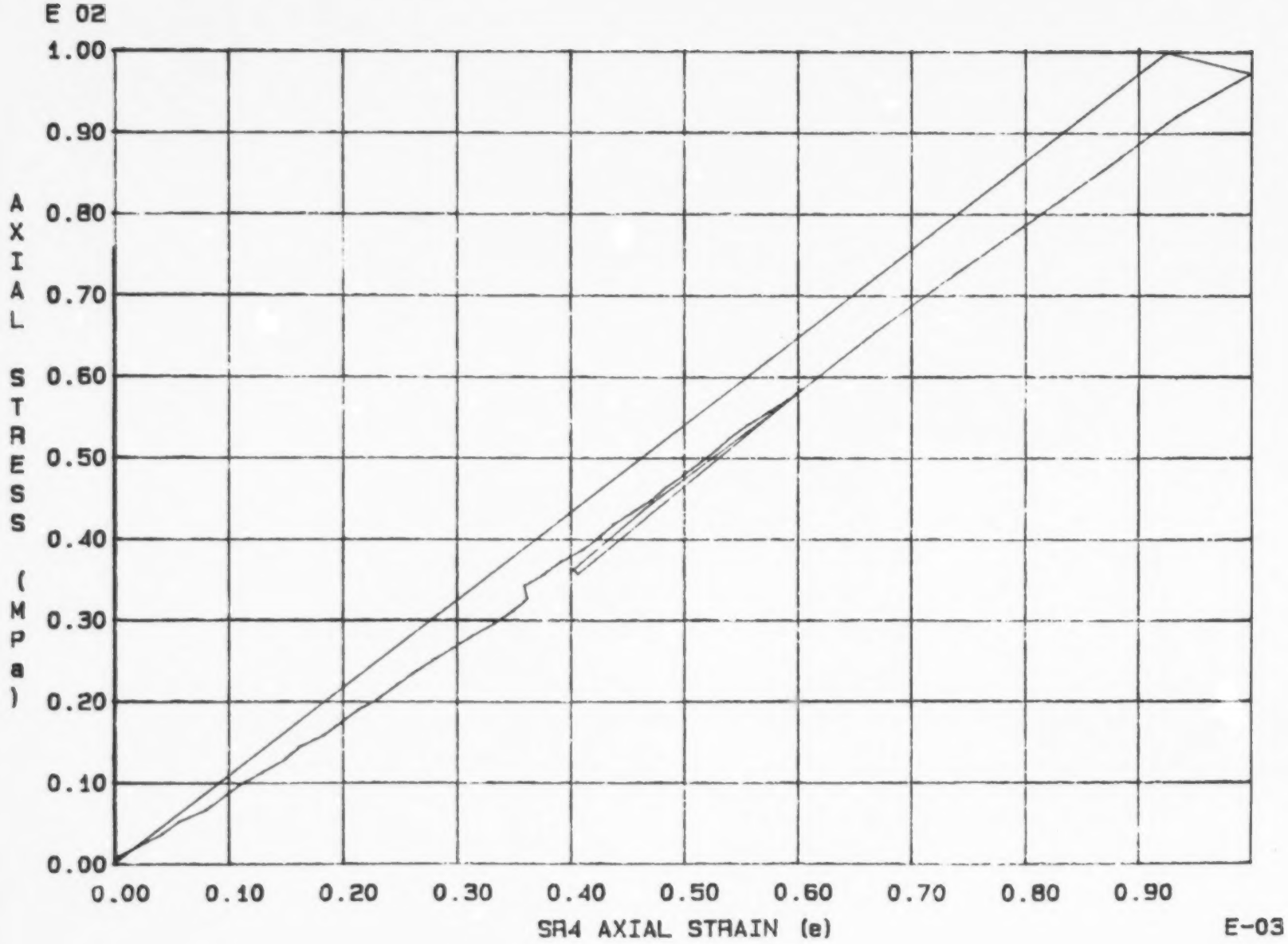

E 02
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
AXIAL STRESS (MPa)
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
SR4 AXIAL STRAIN (e)
E-03

Fig. C-19 E37U

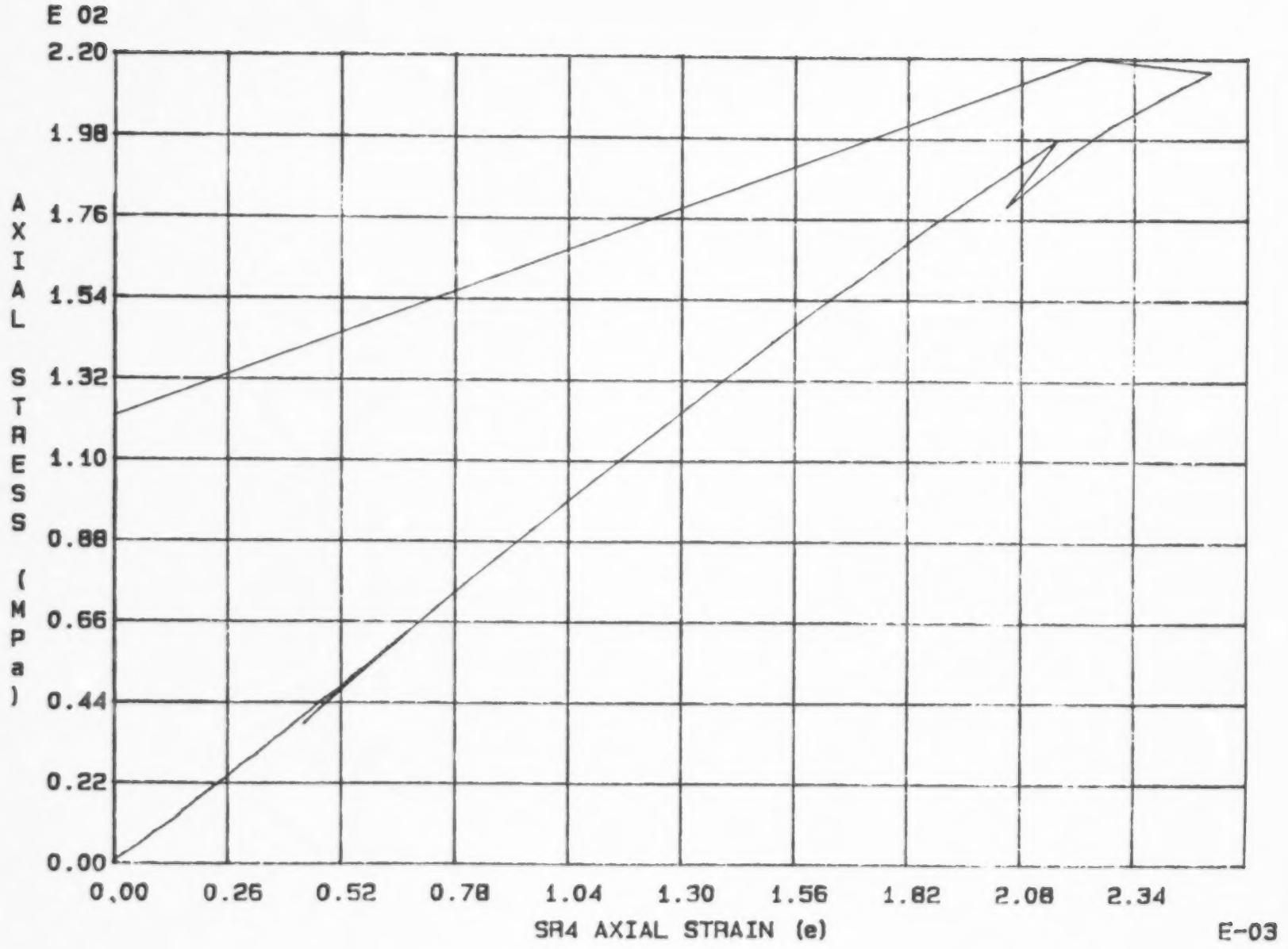

E 02
2.20
1.98
1.76
1.54
1.32
1.10
0.88
0.66
0.44
0.22
0.00
AXIAL STRESS (MPa)
0.00
0.26
0.52
0.78
1.04
1.30
1.56
1.82
2.08
2.34
SR4 AXIAL STRAIN (e)
E-03

Fig. C-20 E39U

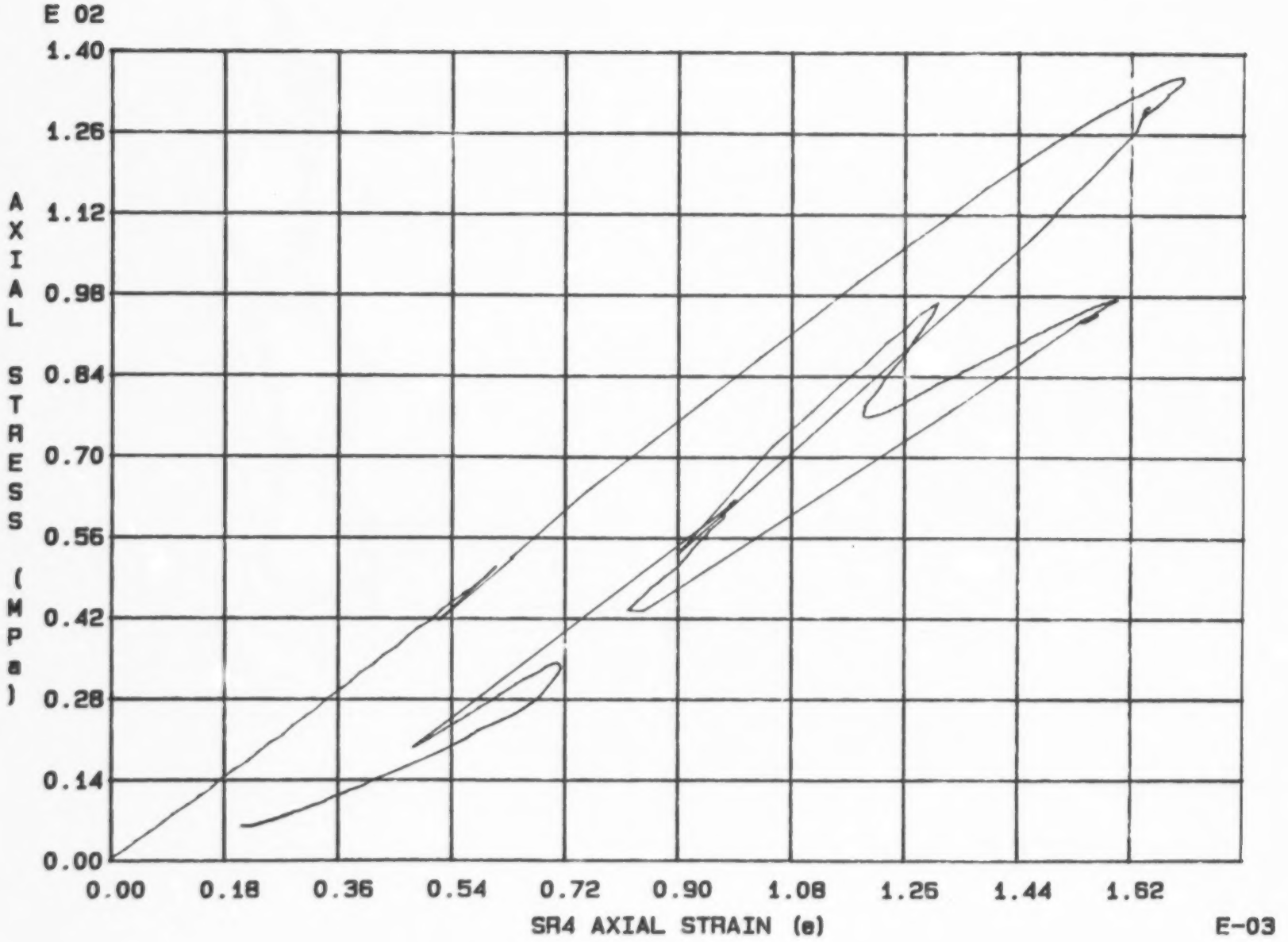
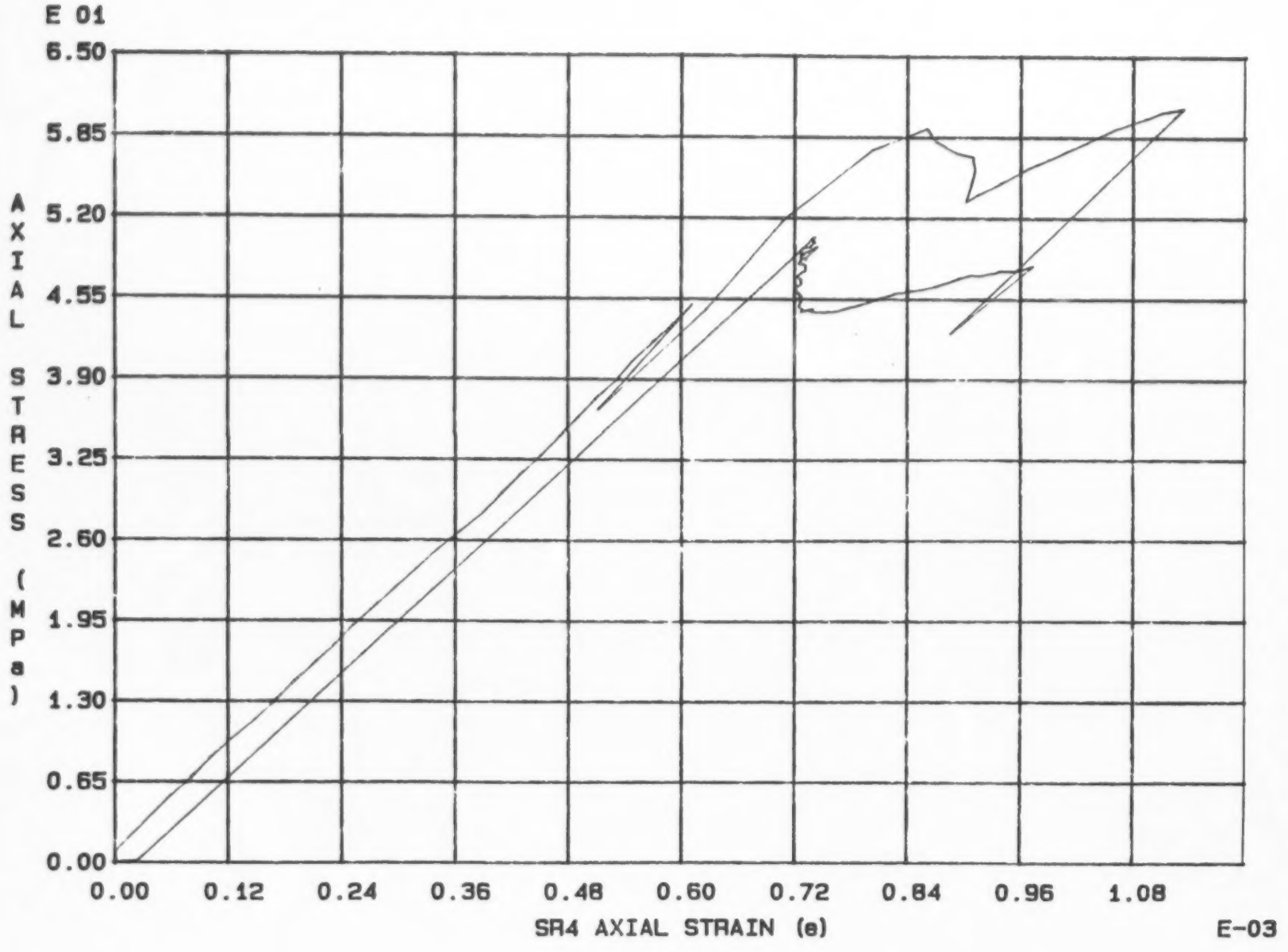

E 02
1.40
1.26
1.12
0.98
0.84
0.70
0.56
0.42
0.28
0.14
0.00
AXIAL STRESS (MPa)
0.00
0.18
0.36
0.54
0.72
0.90
1.08
1.26
1.44
1.62
SR4 AXIAL STRAIN (e)
E-03

Fig. C-21 E41U


E 01
6.50
5.85
5.20
4.55
3.90
3.25
2.60
1.95
1.30
0.65
0.00
AXIAL STRESS (MPa)
0.00
0.12
0.24
0.36
0.48
0.60
0.72
0.84
0.96
1.08
SR4 AXIAL STRAIN (e)
E-03

E43U

Fig. C-22

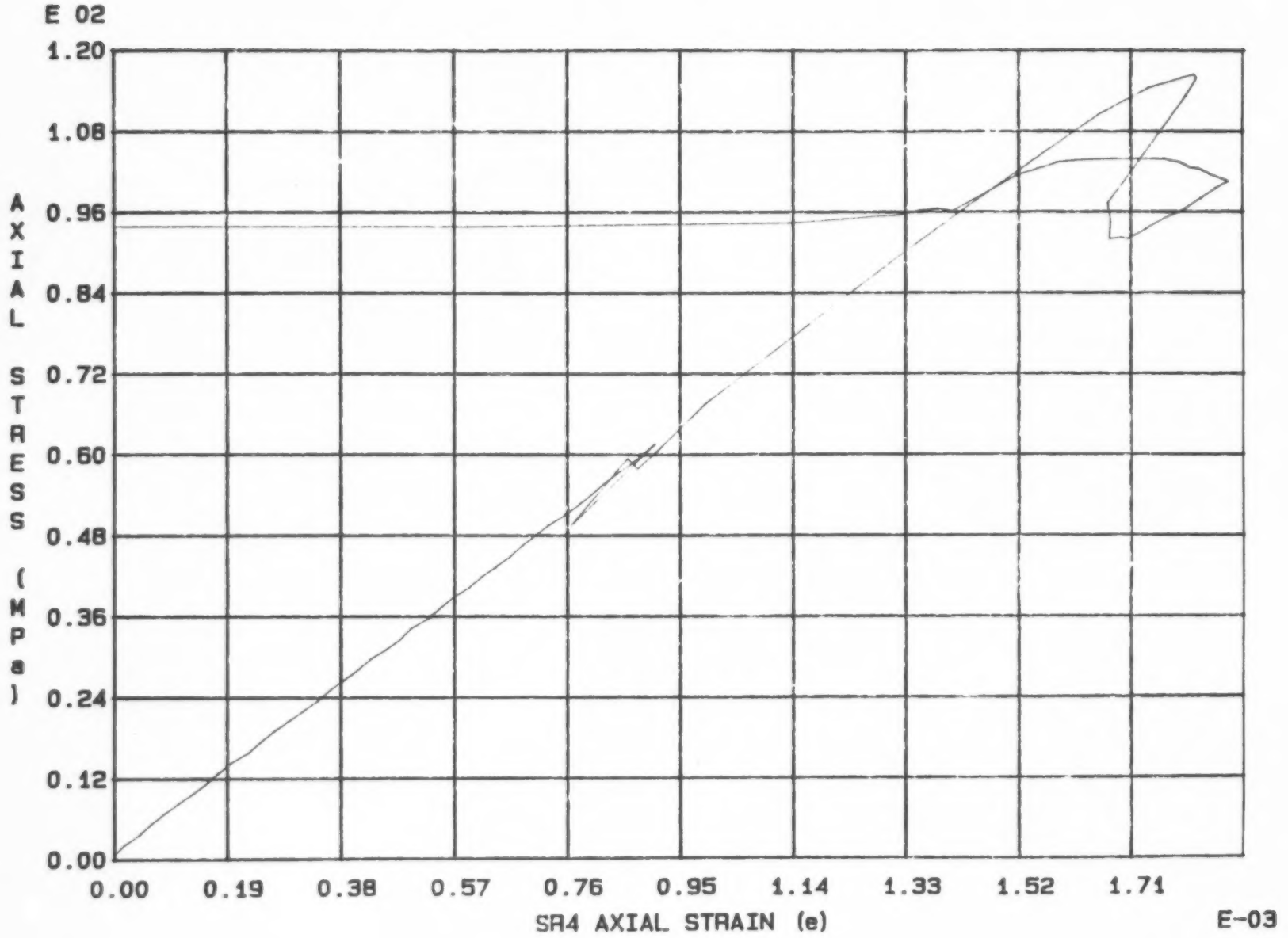

E 02
1.20
1.08
0.96
0.84
0.72
0.60
0.48
0.36
0.24
0.12
0.00
AXIAL STRESS (MPa)
0.00
0.19
0.38
0.57
0.76
0.95
1.14
1.33
1.52
1.71
SR4 AXIAL STRAIN (e)
E-03

Fig. C-23 E45U

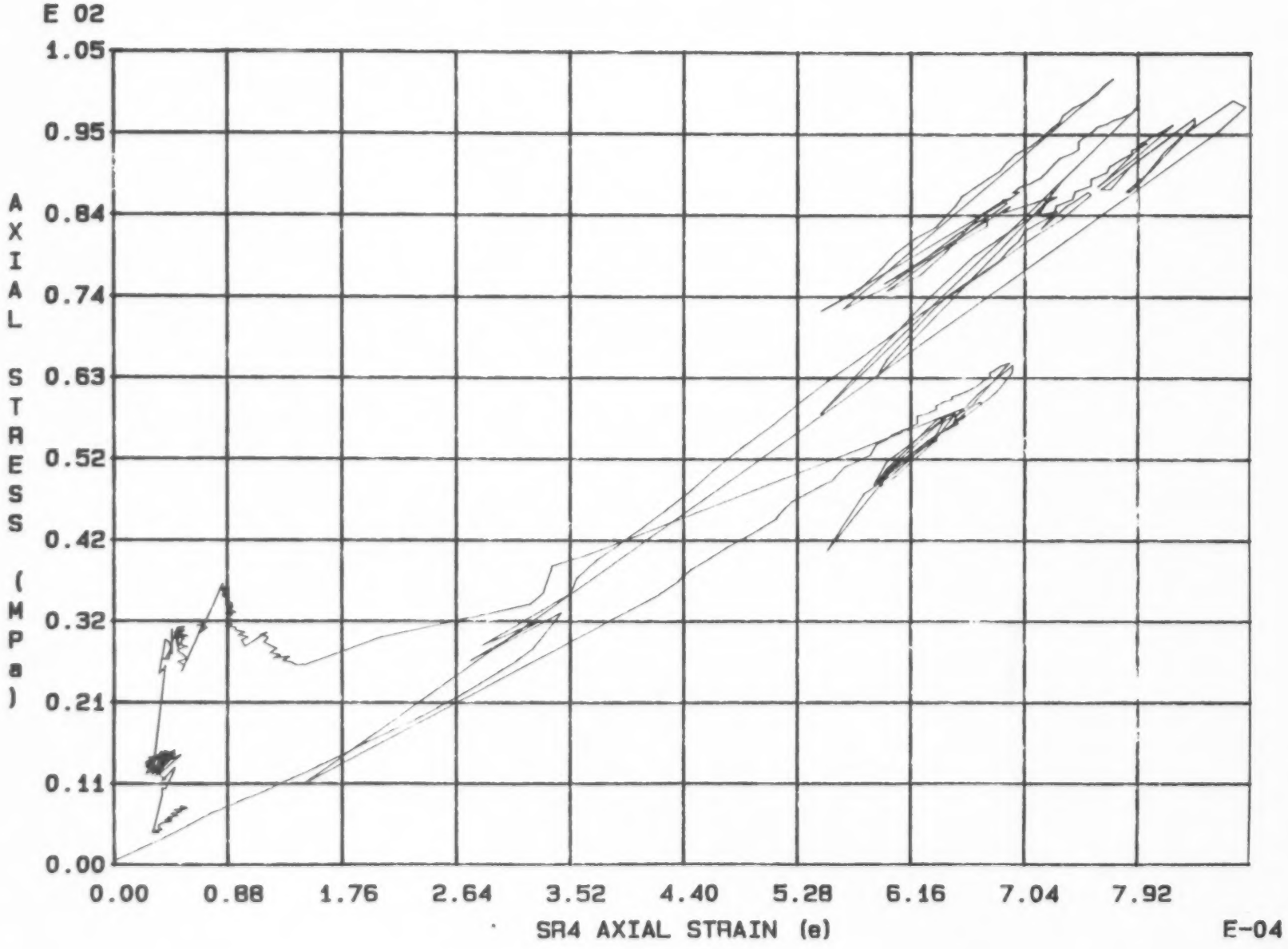

E 02
1.05
0.95
0.84
0.74
0.63
0.52
0.42
0.32
0.21
0.11
0.00
AXIAL STRESS (MPa)
0.00
0.88
1.76
2.64
3.52
4.40
5.28
6.16
7.04
7.92
SR4 AXIAL STRAIN (e)
E-04

Fig. C-24 E47U

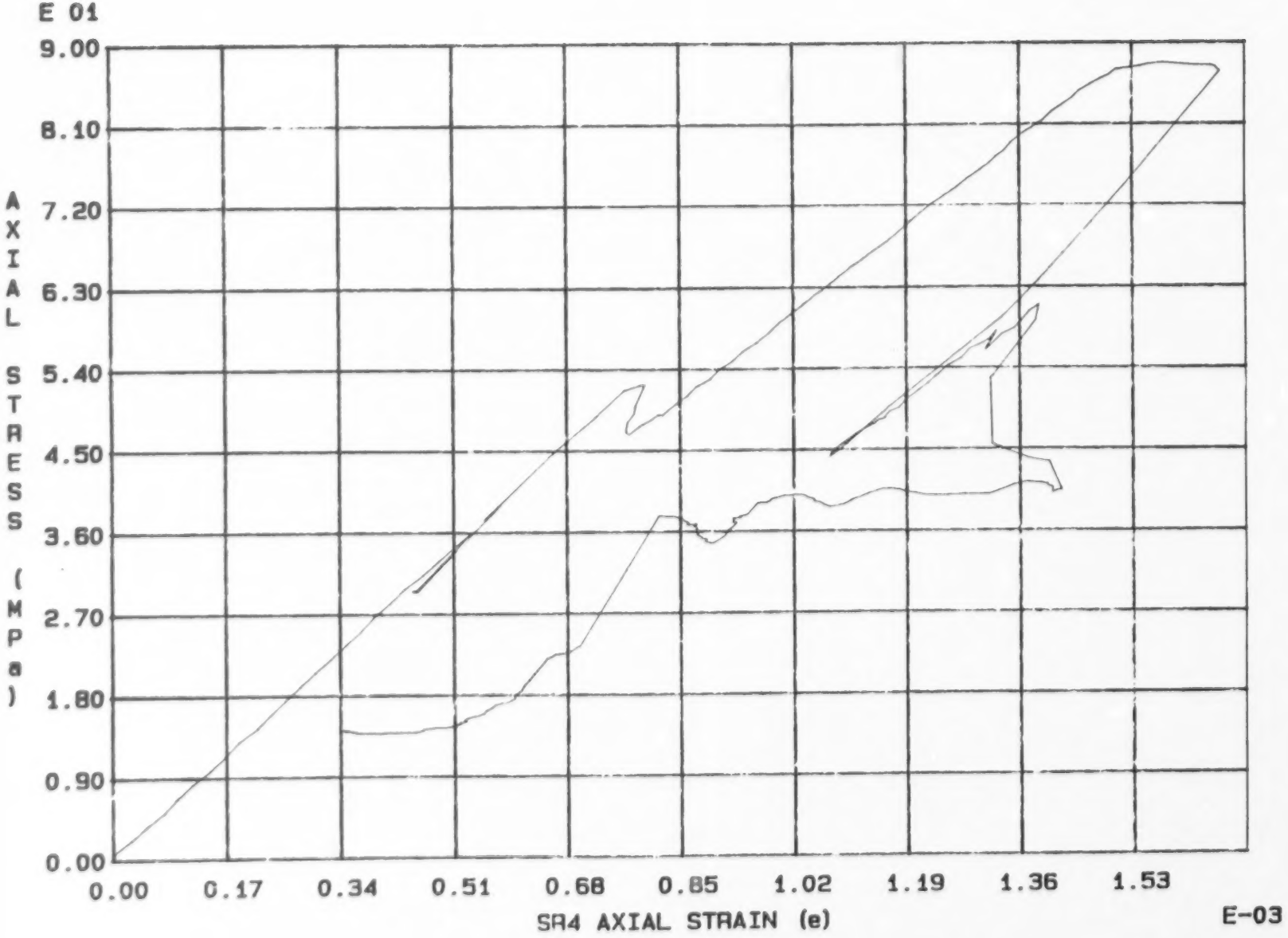

E 01
9.00
8.10
7.20
6.30
5.40
4.50
3.60
2.70
1.80
0.90
0.00
AXIAL STRESS (MPa)
0.00
0.17
0.34
0.51
0.68
0.85
1.02
1.19
1.36
1.53
SR4 AXIAL STRAIN (e)
E-03

Fig. C-25 E49U

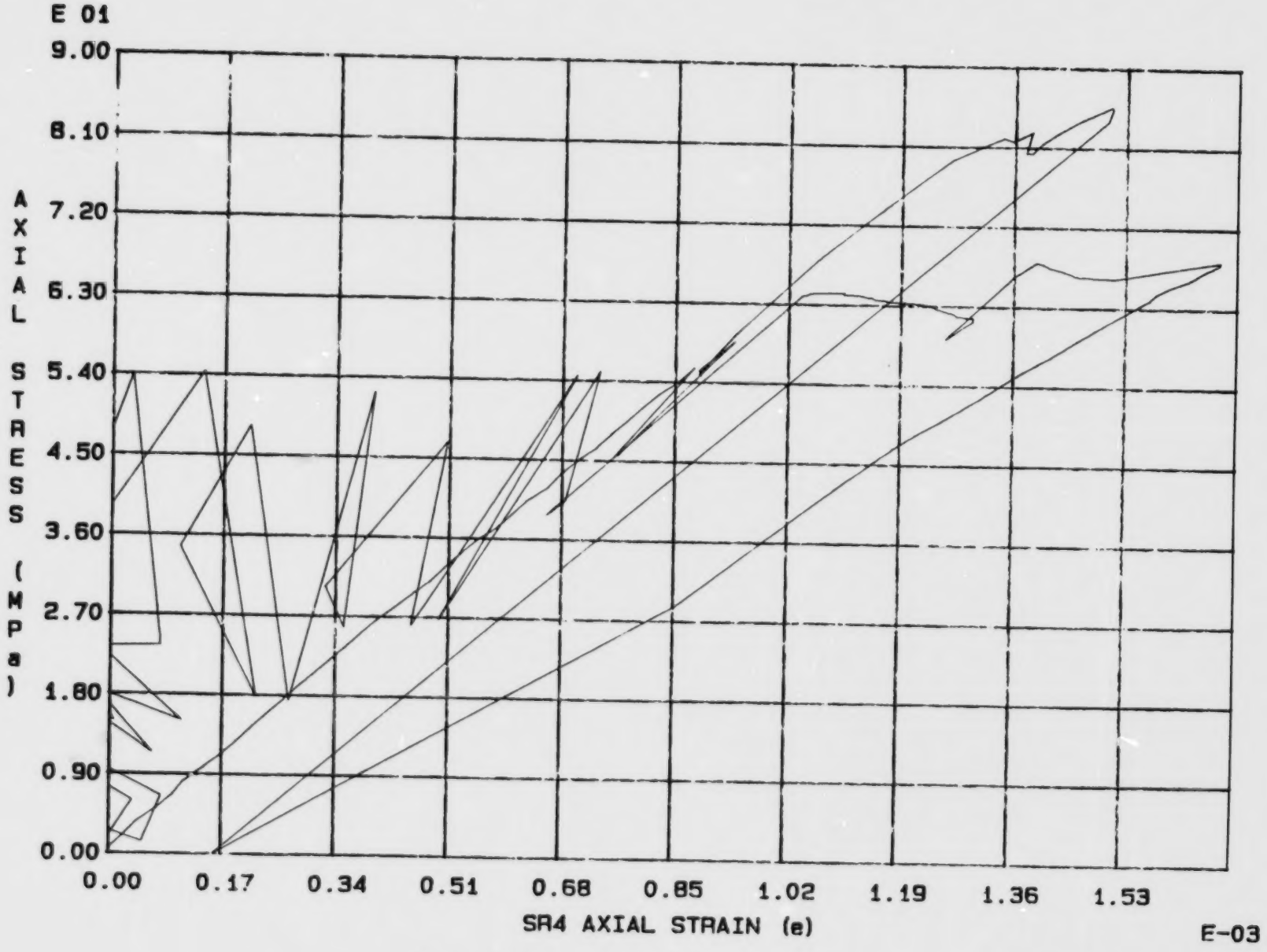

E 01
9.00
8.10
7.20
6.30
5.40
4.50
3.60
2.70
1.80
0.90
0.00
AXIAL STRESS (MPa)
0.00
0.17
0.34
0.51
0.68
0.85
1.02
1.19
1.36
1.53
SR4 AXIAL STRAIN (e)
E-03

Fig. C-26 E51U

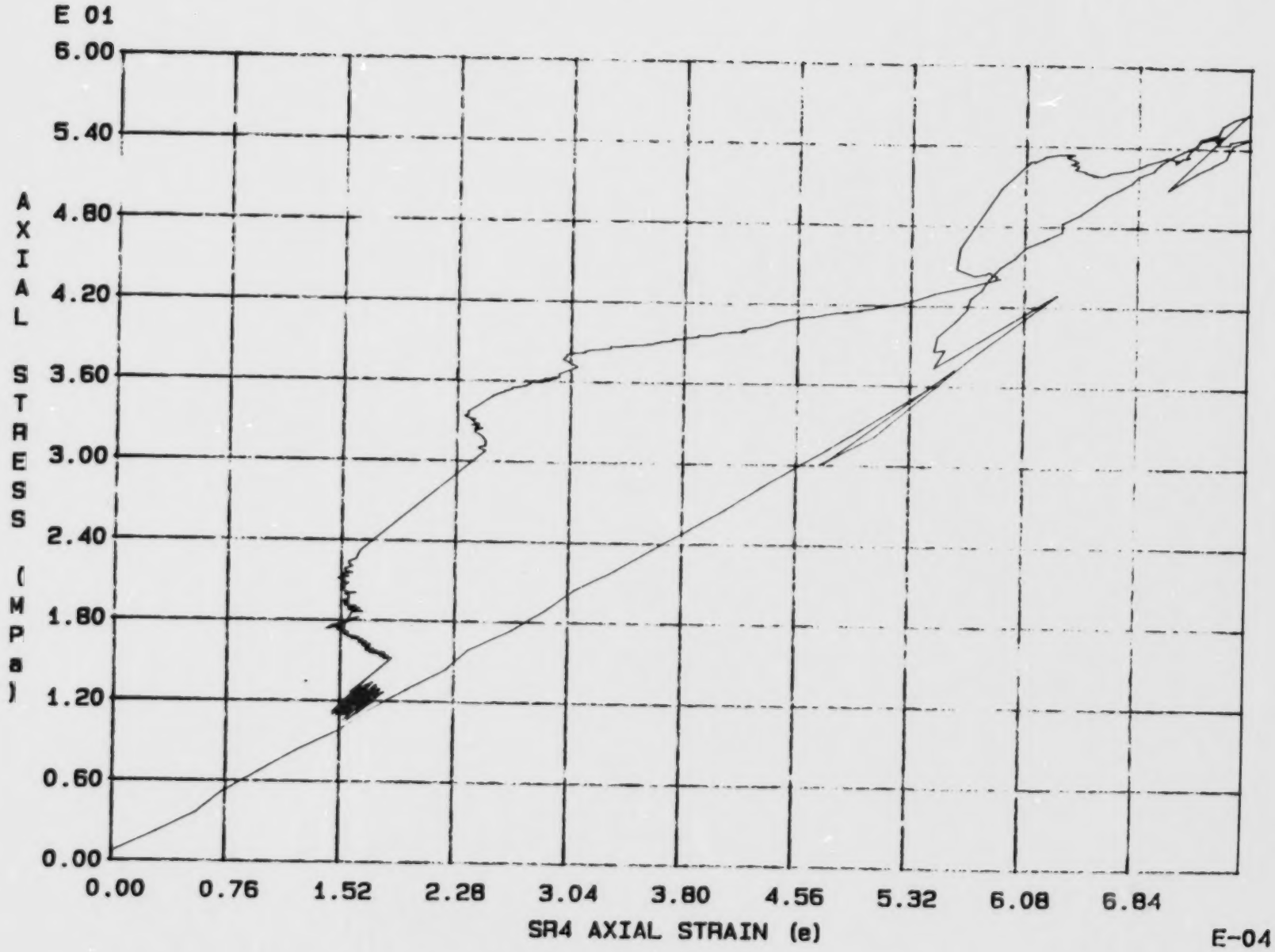

E 01
6.00
5.40
4.80
4.20
3.60
3.00
2.40
1.80
1.20
0.60
0.00
AXIAL STRESS (MPa)
0.00
0.76
1.52
2.28
3.04
3.80
4.56
5.32
6.08
6.84
SR4 AXIAL STRAIN (e)
E-04

Fig. C-27 E53U

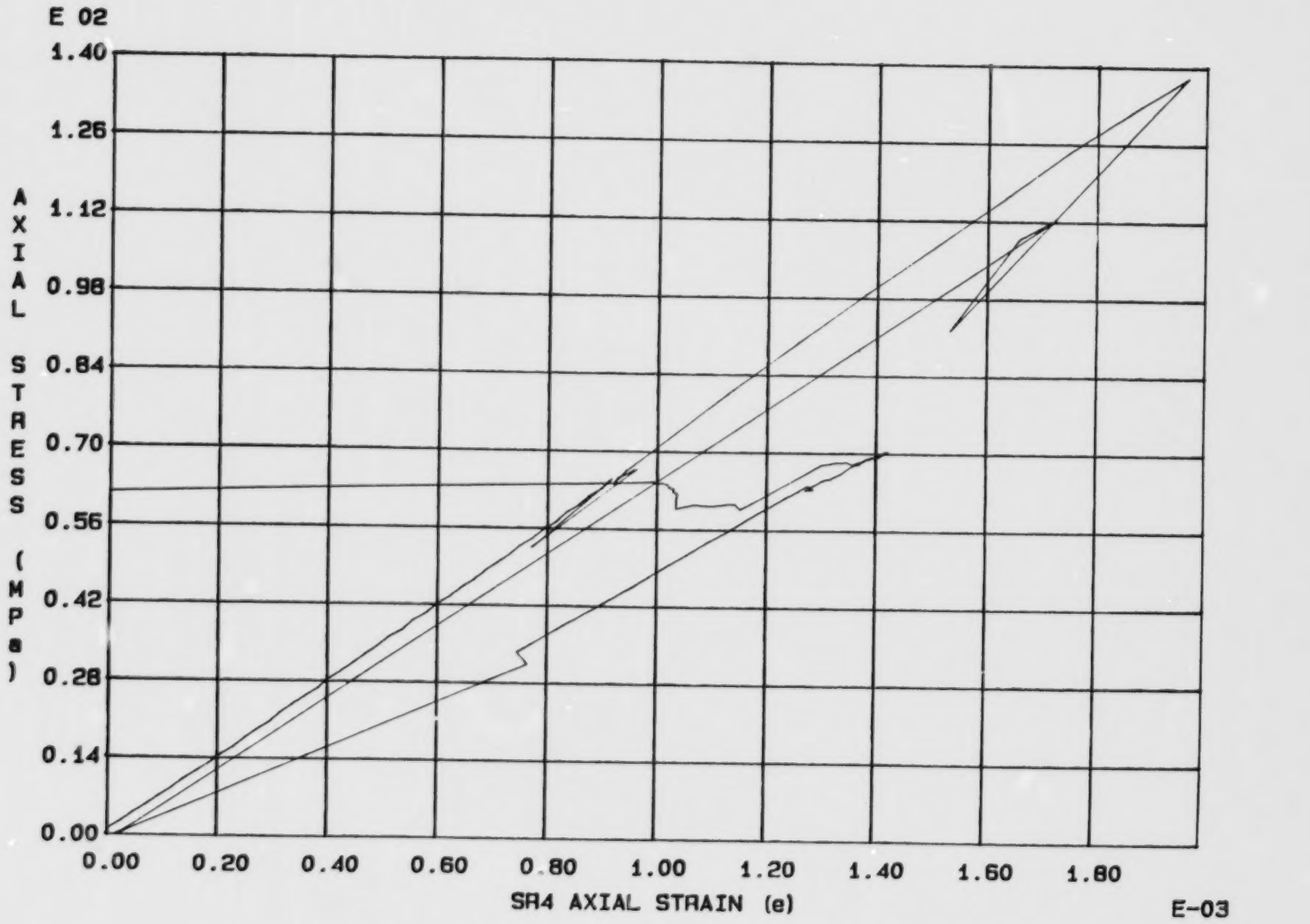

E 02
1.40
1.26
1.12
0.98
0.84
0.70
0.56
0.42
0.28
0.14
0.00
AXIAL STRESS (MPa)
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
1.60
1.80
SR4 AXIAL STRAIN (e)
E-03

Fig. C-28 E55U

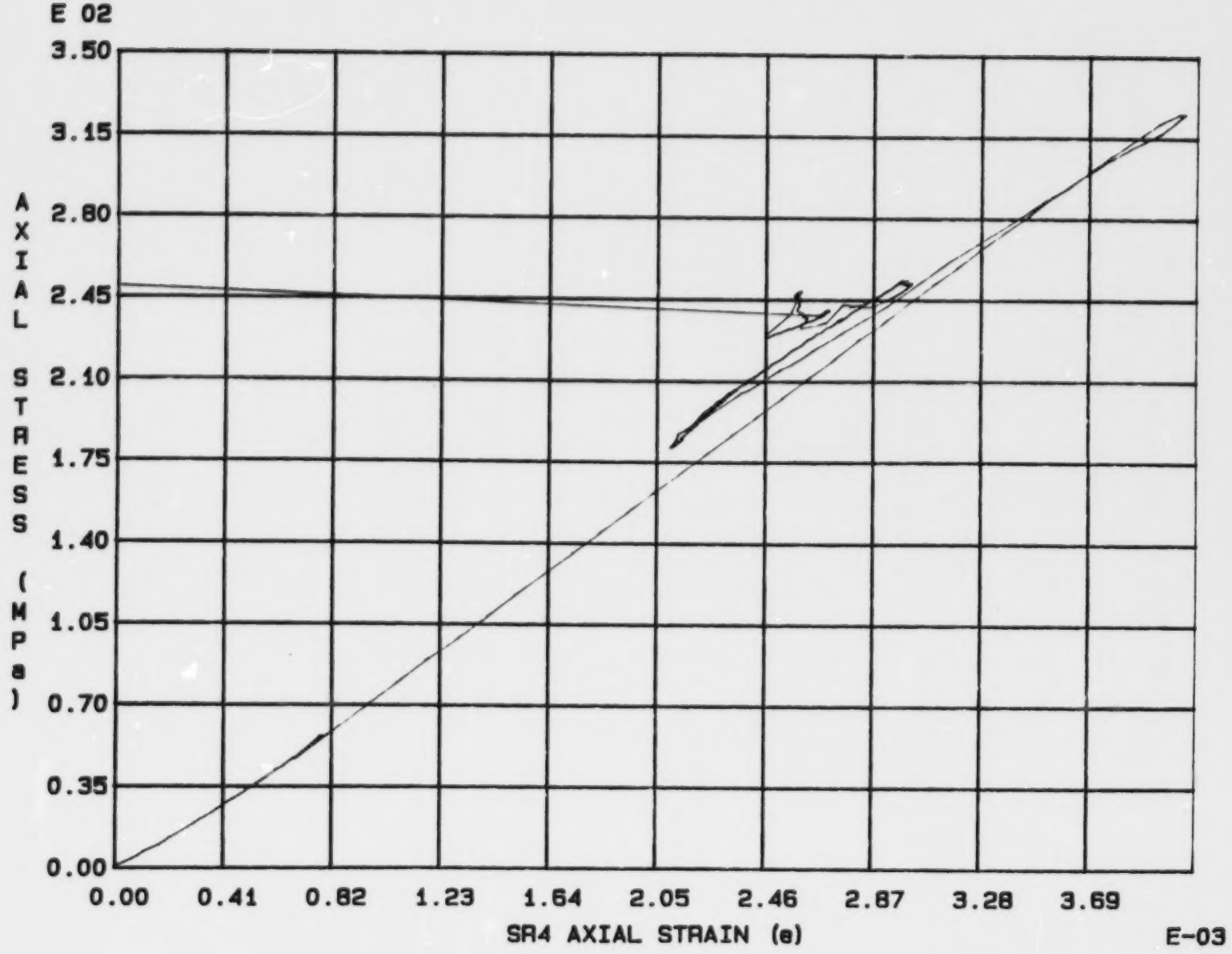

E 02
3.50
3.15
2.80
2.45
2.10
1.75
1.40
1.05
0.70
0.35
0.00
AXIAL STRESS (MPa)
0.00
0.41
0.82
1.23
1.64
2.05
2.46
2.87
3.28
3.69
SR4 AXIAL STRAIN (e)
E-03

Fig. C-29 E57U

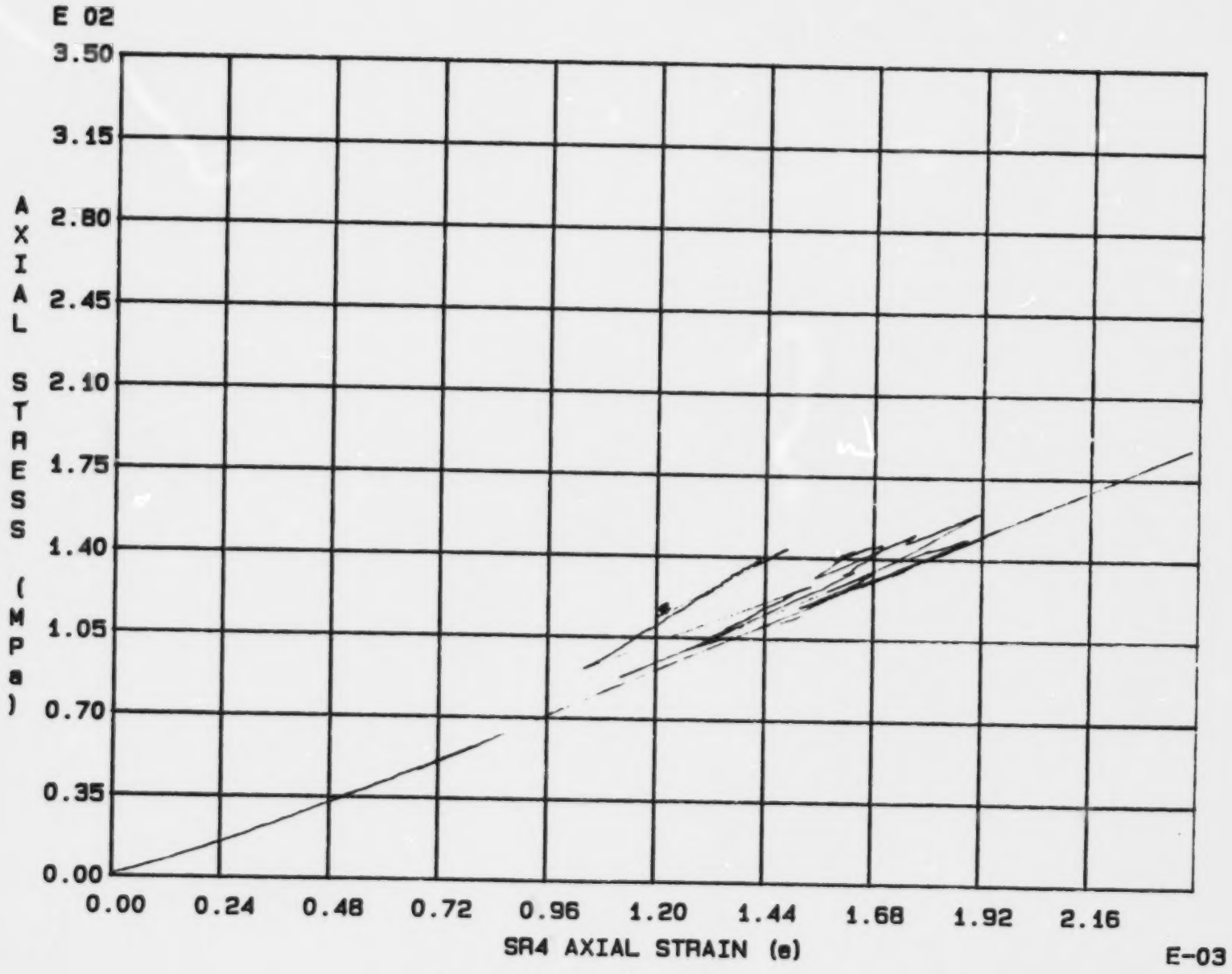

E 02
3.50
3.15
2.80
2.45
2.10
1.75
1.40
1.05
0.70
0.35
0.00
AXIAL STRESS (MPa)
0.00
0.24
0.48
0.72
0.96
1.20
1.44
1.68
1.92
2.16
SR4 AXIAL STRAIN (e)
E-03

Fig. C-30 E58U

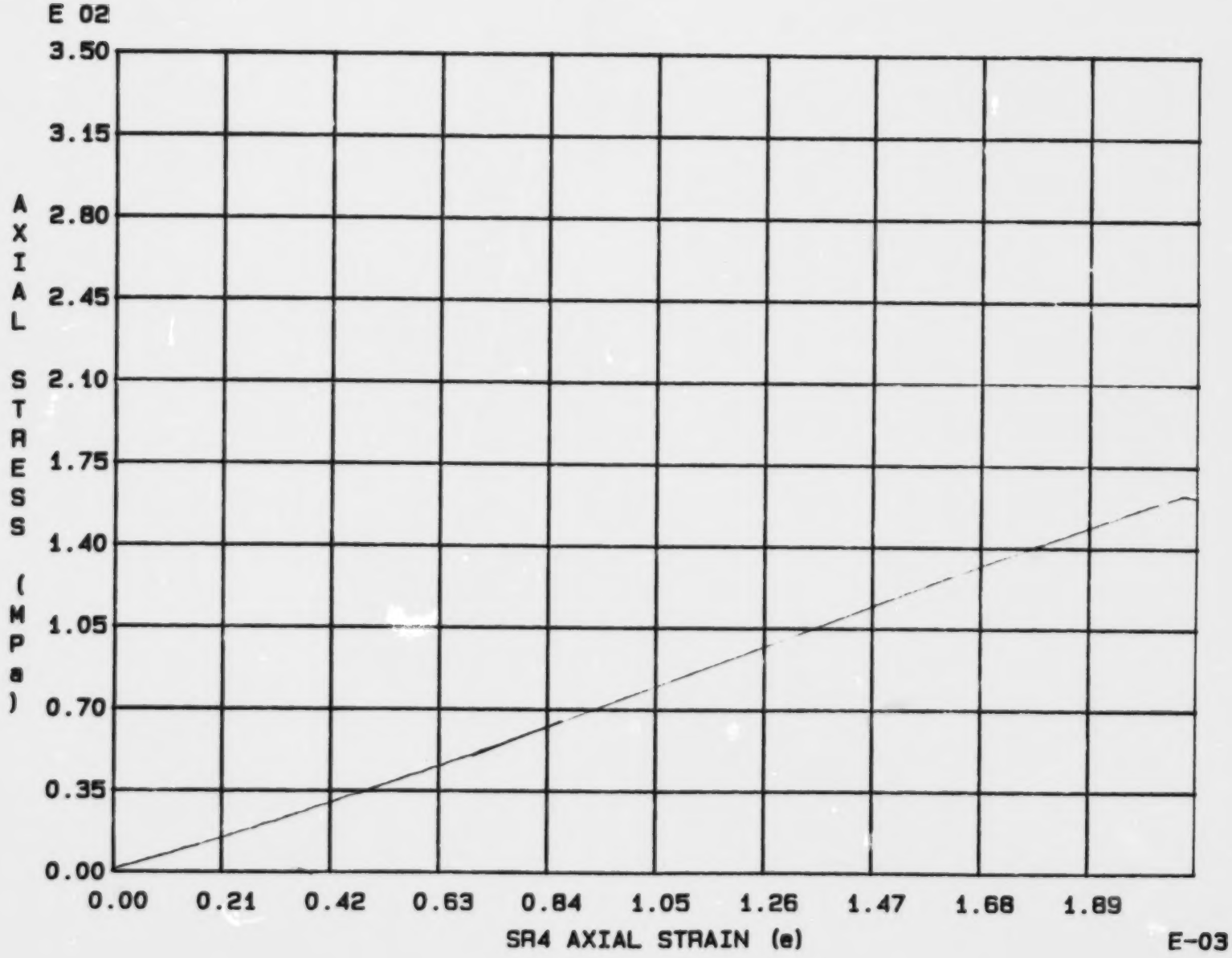

E 02
3.50
3.15
2.80
2.45
2.10
1.75
1.40
1.05
0.70
0.35
0.00
AXIAL STRESS (MPa)
0.00
0.21
0.42
0.63
0.84
1.05
1.26
1.47
1.68
1.89
SR4 AXIAL STRAIN (e)
E-03

Fig. C-31 E59U

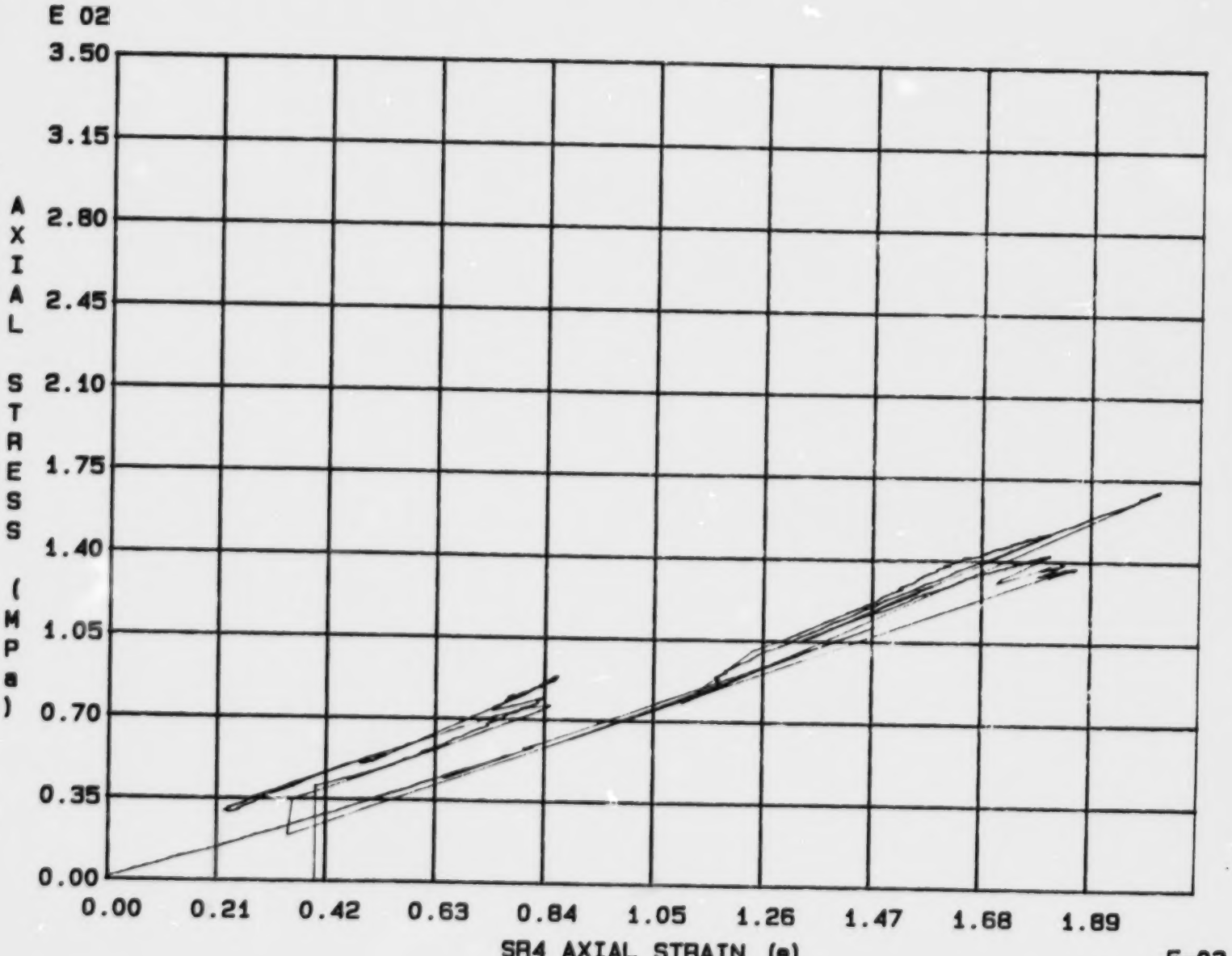

E 02
3.50
3.15
2.80
2.45
2.10
1.75
1.40
1.05
0.70
0.35
0.00
AXIAL STRESS (MPa)
0.00
0.21
0.42
0.63
0.84
1.05
1.26
1.47
1.68
1.89
SR4 AXIAL STRAIN (e)
E-03

Fig. C-32 E60U

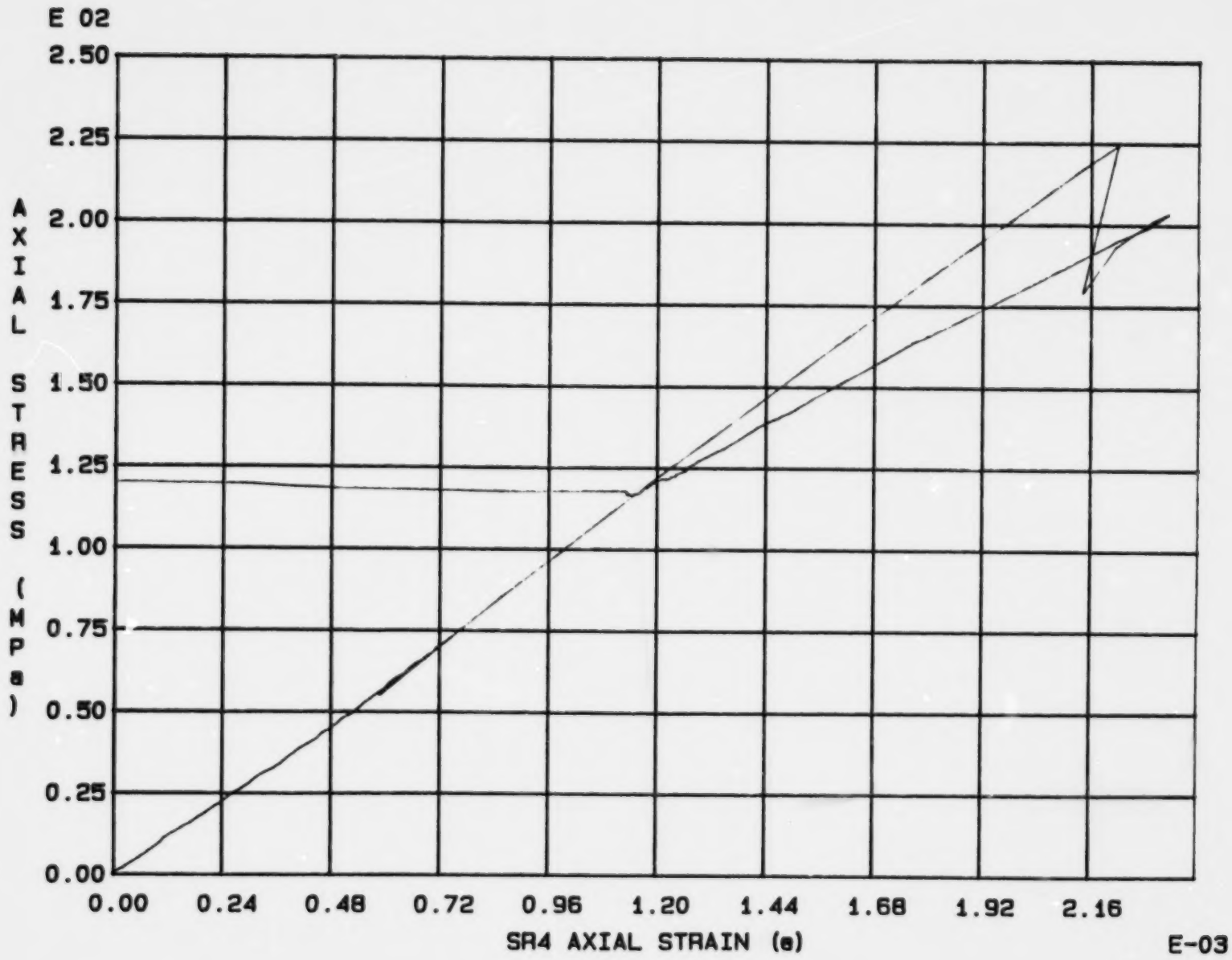

E 02
2.50
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
AXIAL STRESS (MPa)
0.00
0.24
0.48
0.72
0.96
1.20
1.44
1.68
1.92
2.16
SR4 AXIAL STRAIN (e)
E-03

Fig. C-33 E72U

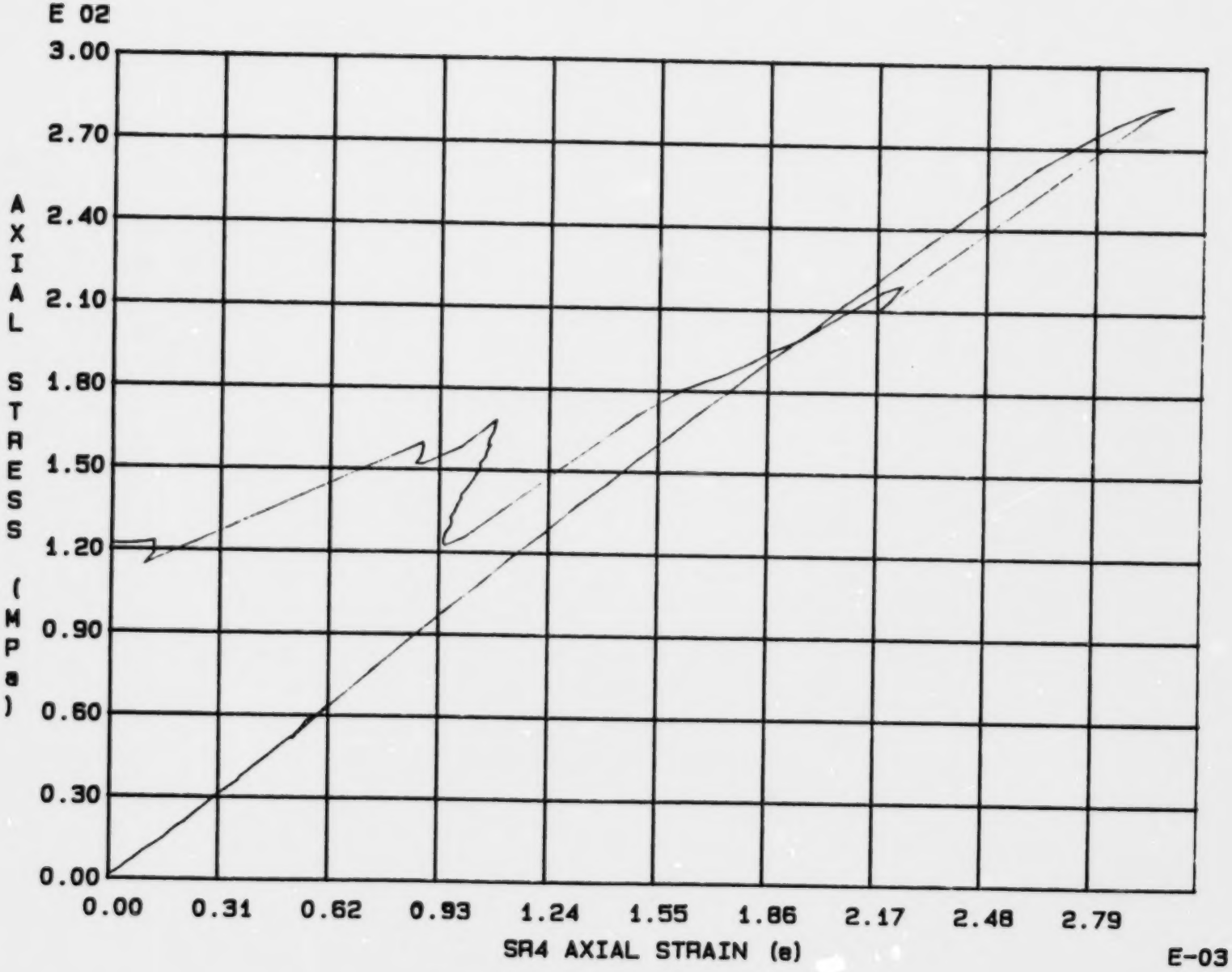

E 02
3.00
2.70
2.40
2.10
1.80
1.50
1.20
0.90
0.60
0.30
0.00
AXIAL STRESS (MPa)
0.00
0.31
0.62
0.93
1.24
1.55
1.86
2.17
2.48
2.79
SR4 AXIAL STRAIN (e)
E-03

Fig. C-34 E73U

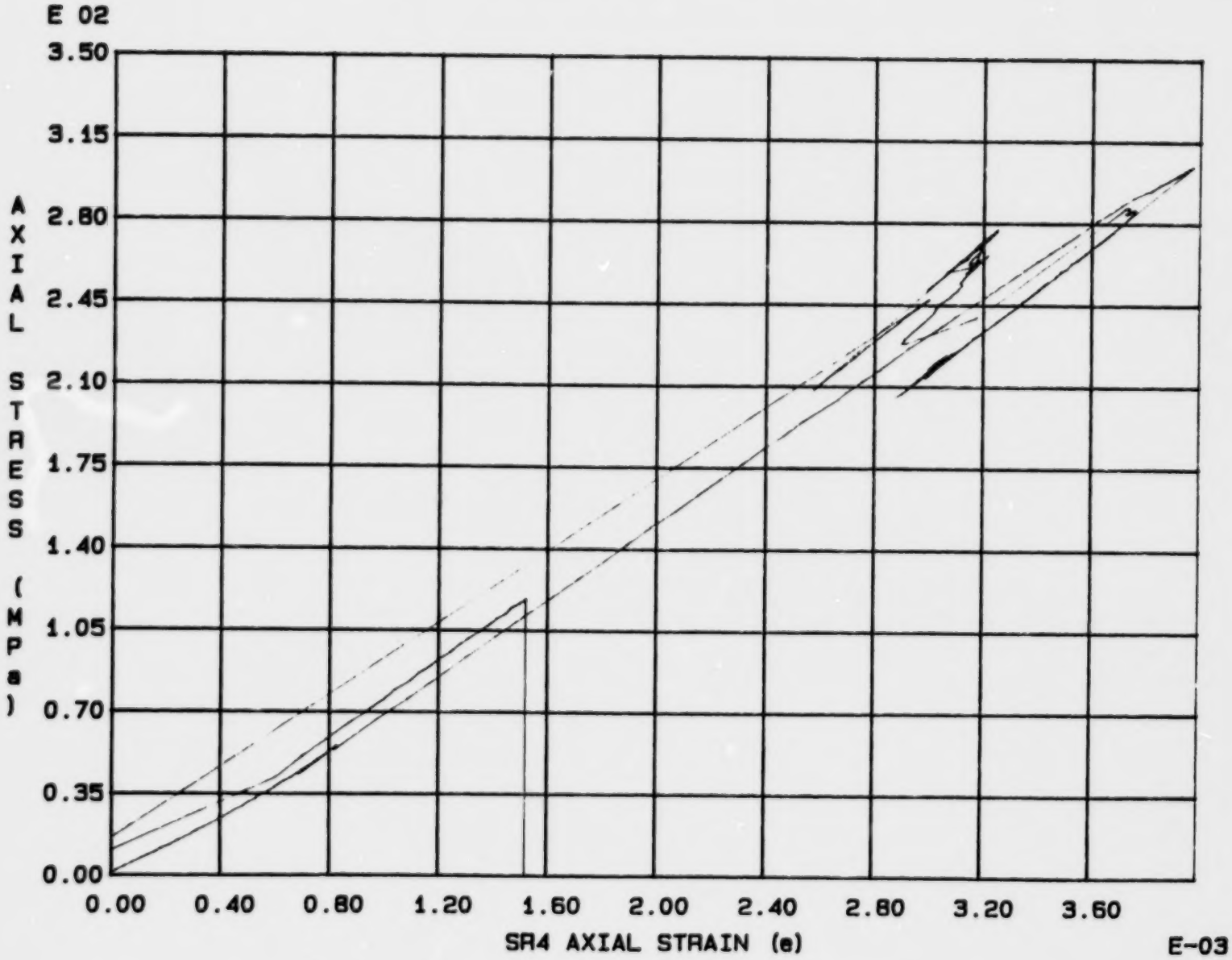

E 02
3.50
3.15
2.80
2.45
2.10
1.75
1.40
1.05
0.70
0.35
0.00
AXIAL STRESS (MPa)
0.00
0.40
0.80
1.20
1.60
2.00
2.40
2.80
3.20
3.60
SR4 AXIAL STRAIN (e)
E-03

Fig. C-35 E74U

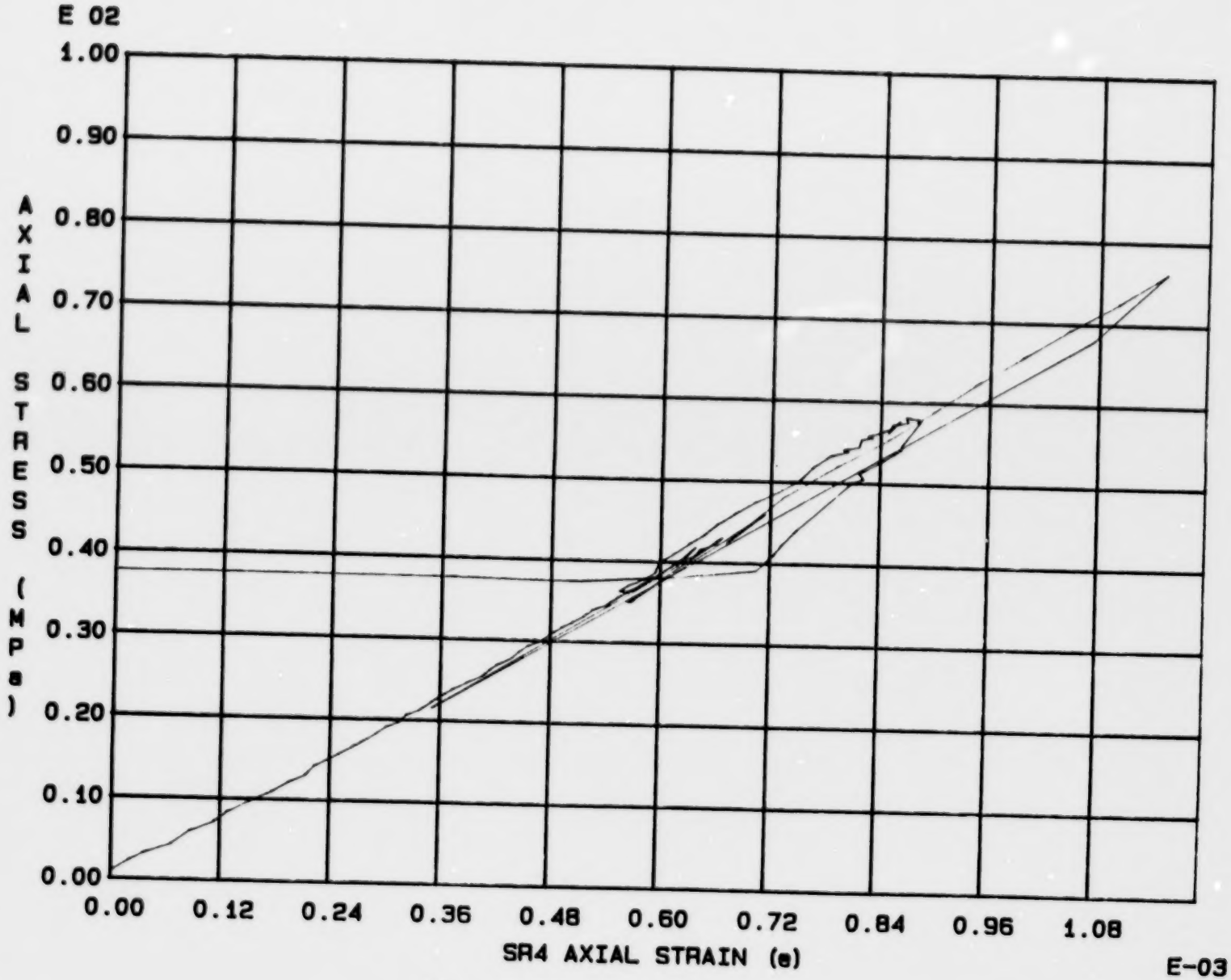

E 02
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
AXIAL STRESS (MPa)
0.00
0.12
0.24
0.36
0.48
0.60
0.72
0.84
0.96
1.08
SR4 AXIAL STRAIN (e)
E-03

Fig. C-36 E75U

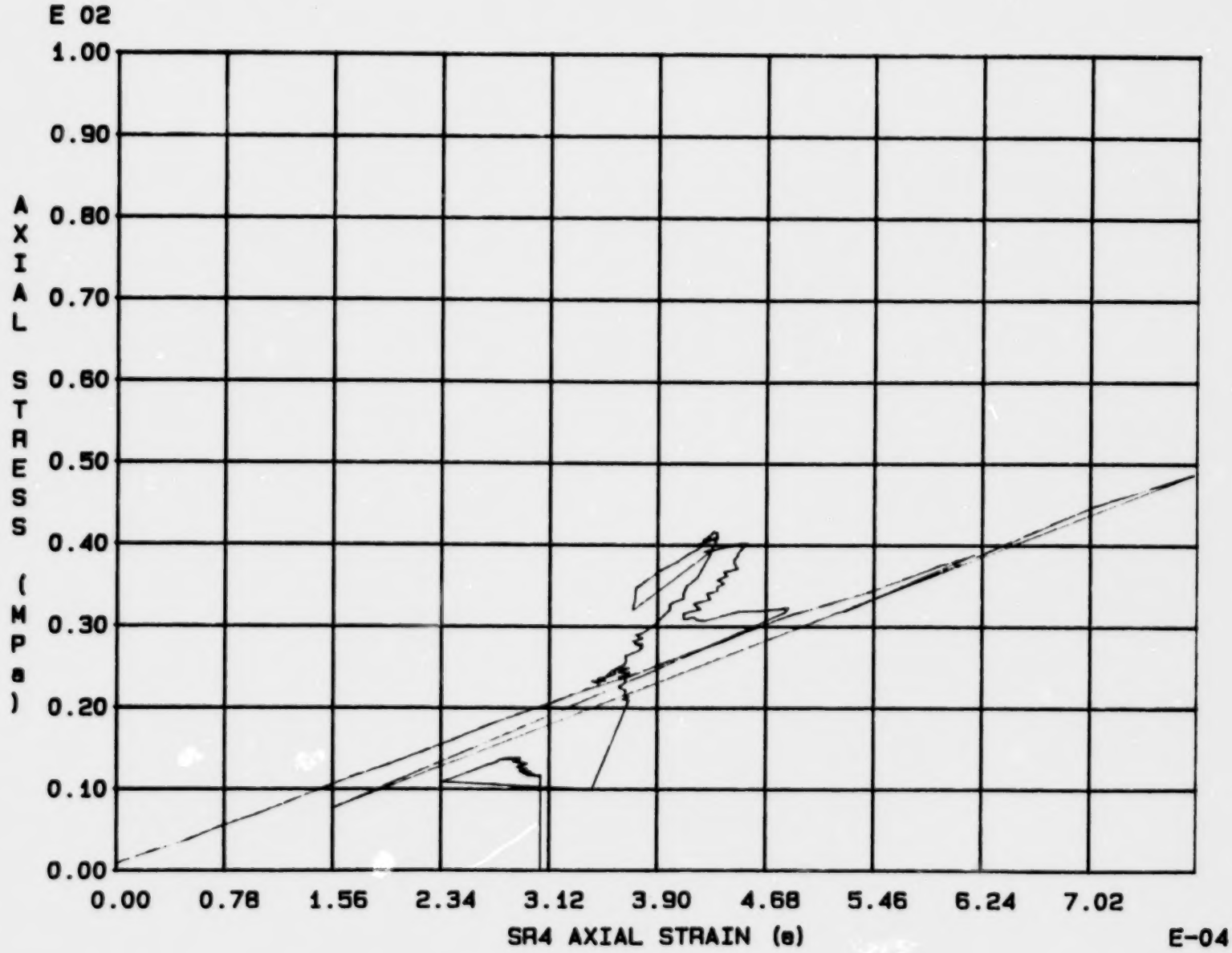

E 02
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
AXIAL STRESS (MPa)
0.00
0.78
1.56
2.34
3.12
3.90
4.68
5.46
6.24
7.02
SR4 AXIAL STRAIN (e)
E-04

Fig. C-37 E76U

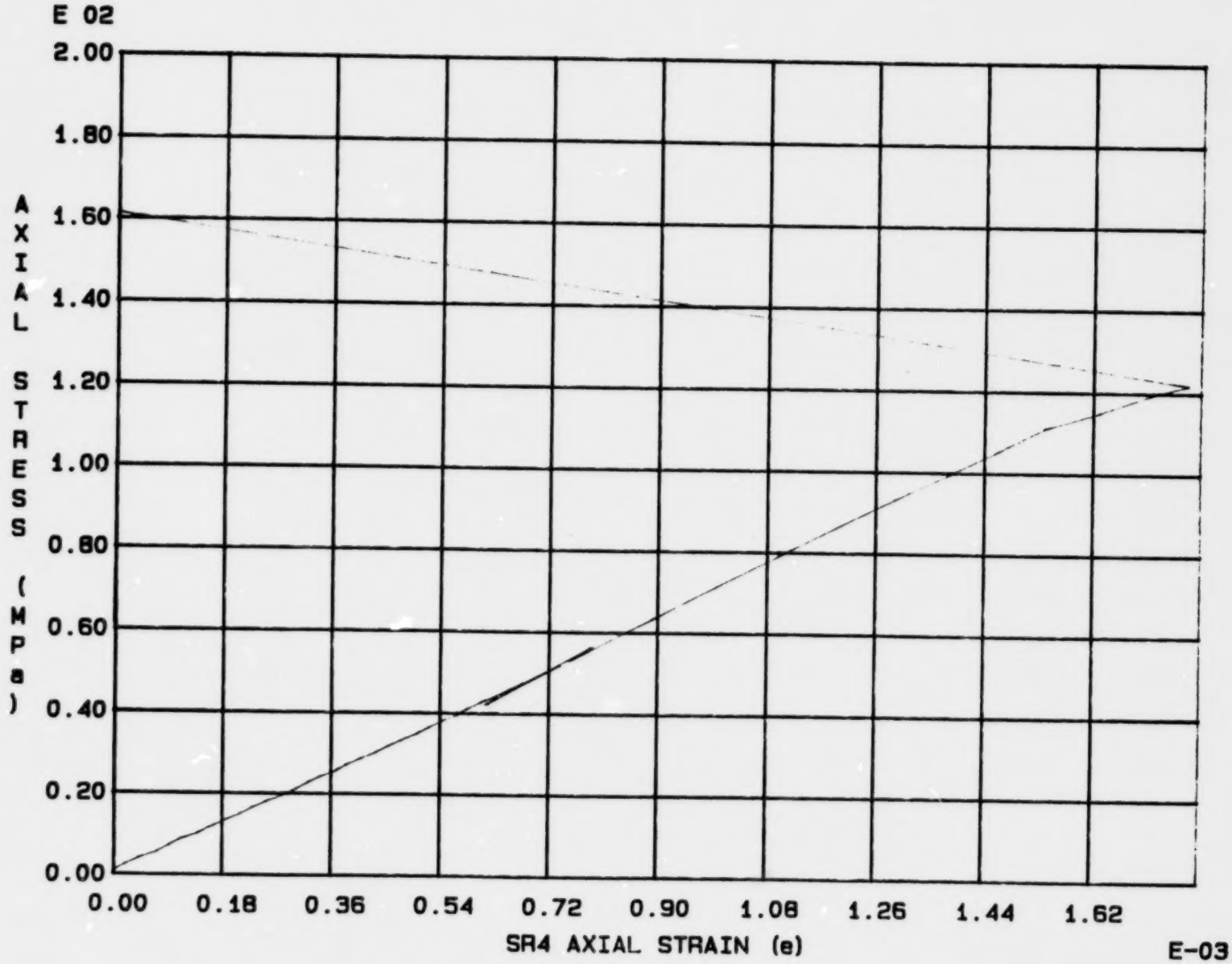

E 02
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
AXIAL STRESS (MPa)
0.00
0.18
0.36
0.54
0.72
0.90
1.08
1.26
1.44
1.62
SR4 AXIAL STRAIN (e)
E-03

Fig. C-38 E77U

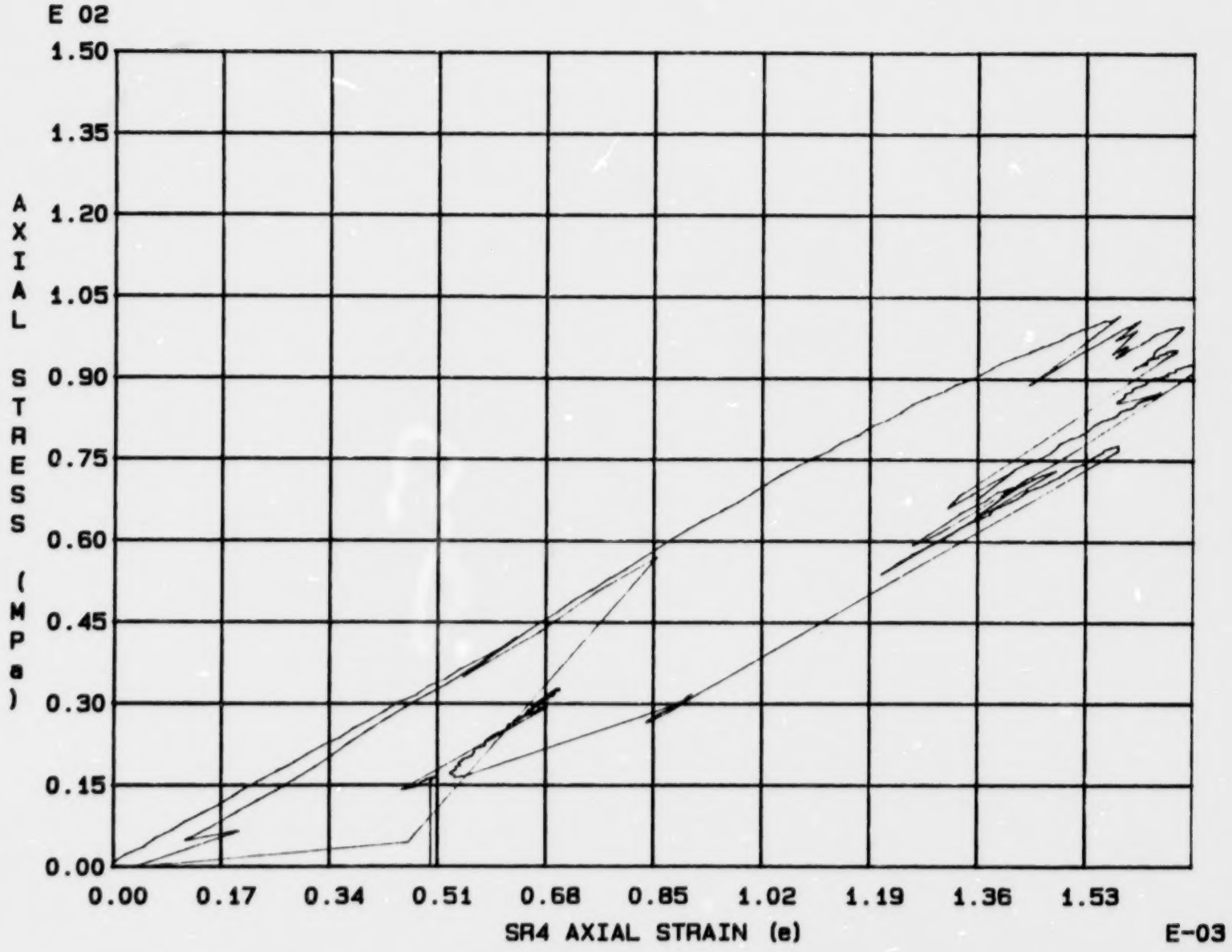

E 02
1.50
1.35
1.20
1.05
0.90
0.75
0.60
0.45
0.30
0.15
0.00
AXIAL STRESS (MPa)
0.00
0.17
0.34
0.51
0.68
0.85
1.02
1.19
1.36
1.53
SR4 AXIAL STRAIN (e)
E-03

Fig. C-39 E78U

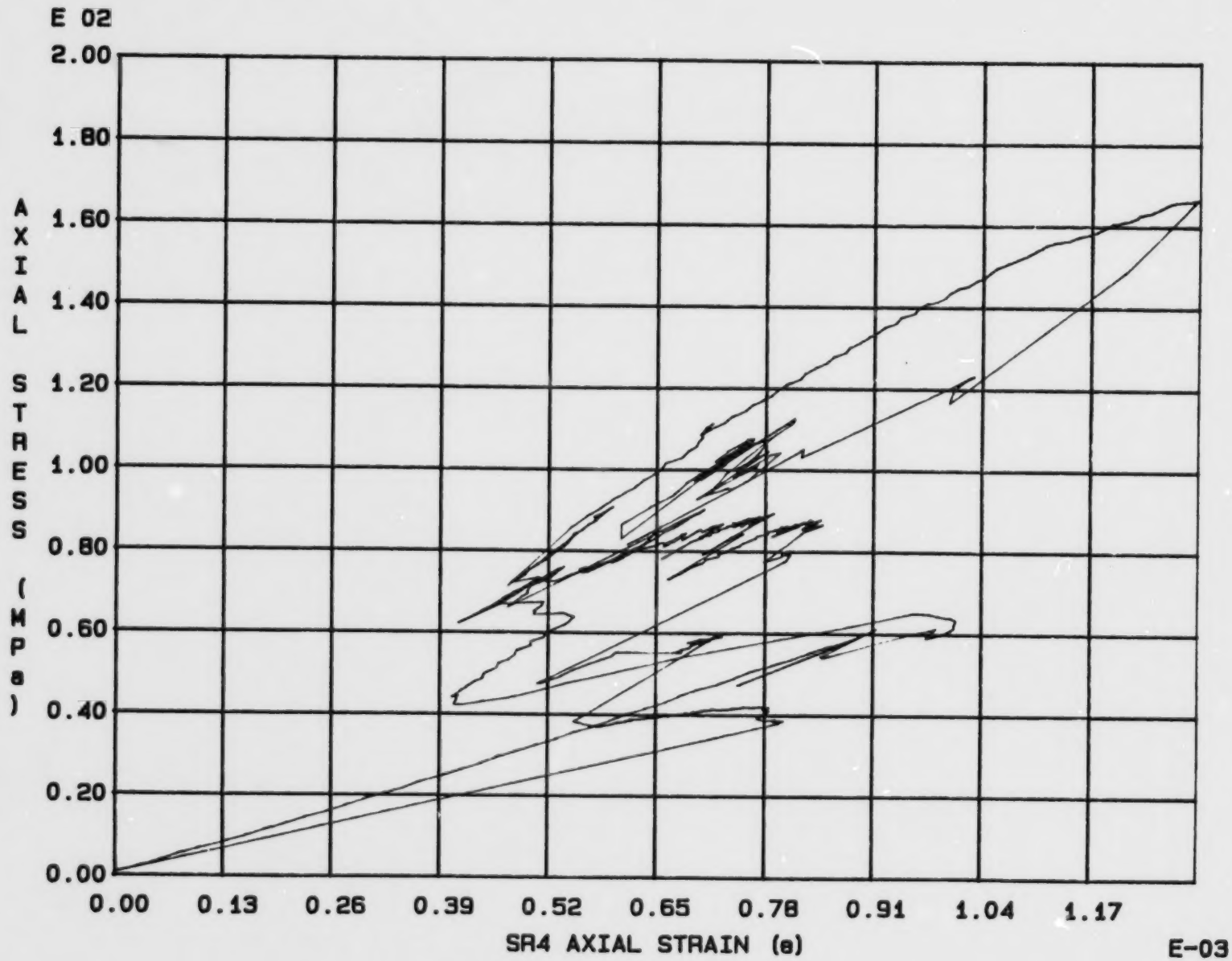

E 02
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
AXIAL STRESS (MPa)
0.00
0.13
0.26
0.39
0.52
0.65
0.78
0.91
1.04
1.17
SR4 AXIAL STRAIN (e)
E-03

Fig. C-40 E79U

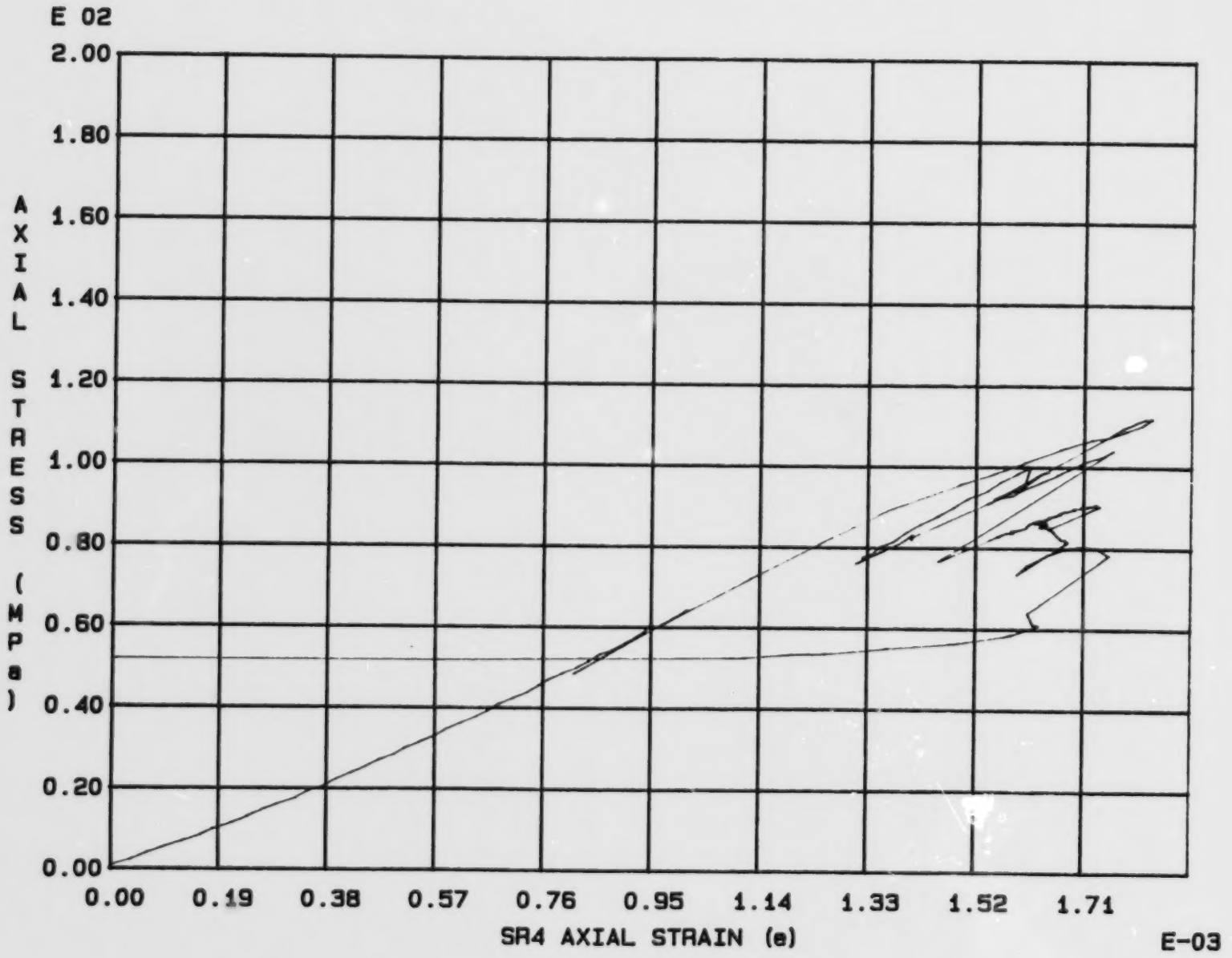

E 02
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
AXIAL STRESS (MPa)
0.00
0.19
0.38
0.57
0.76
0.95
1.14
1.33
1.52
1.71
SR4 AXIAL STRAIN (e)
E-03

Fig. C-41 E80U

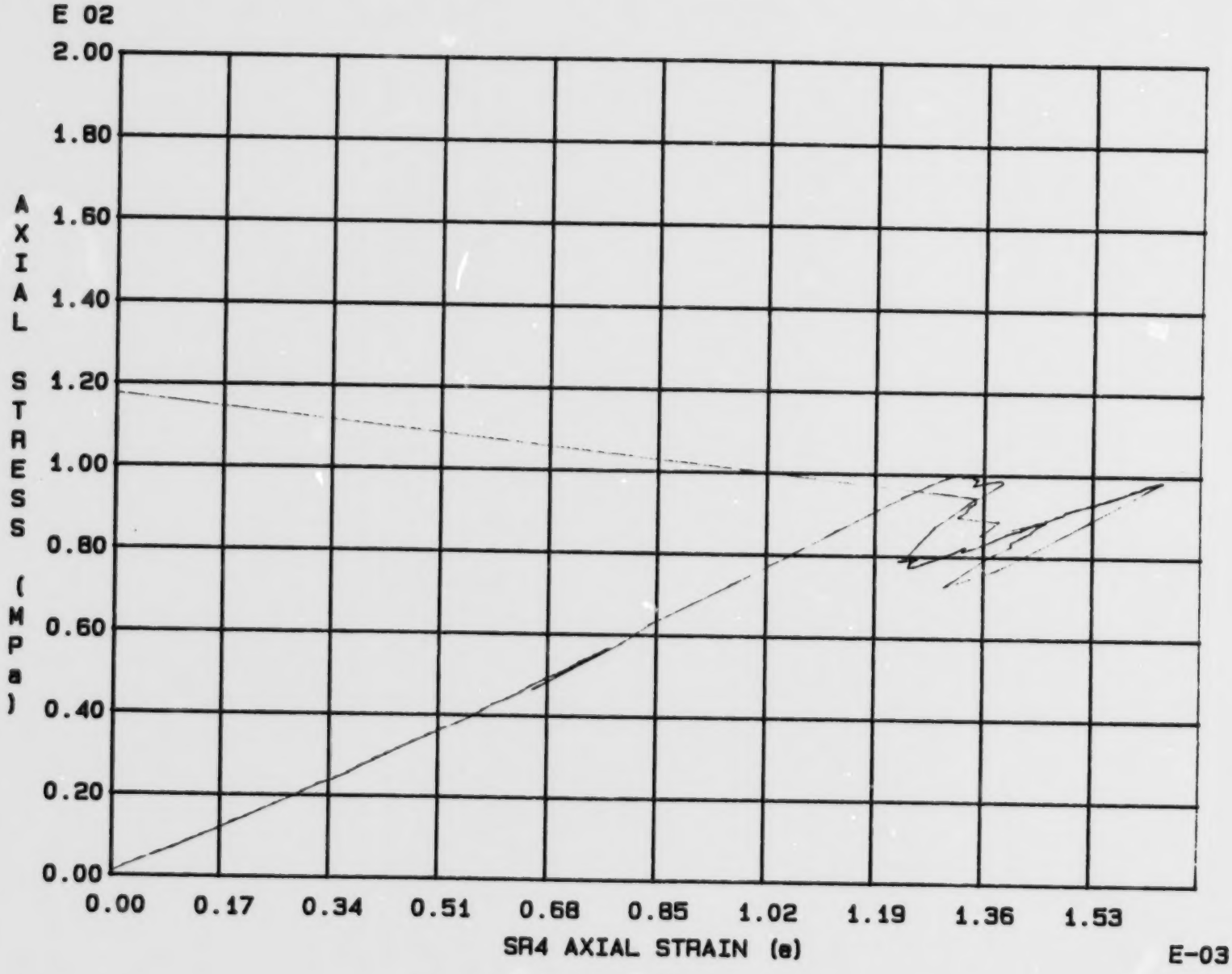

E 02
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
AXIAL STRESS (MPa)
0.00
0.17
0.34
0.51
0.68
0.85
1.02
1.19
1.36
1.53
SR4 AXIAL STRAIN (e)
E-03

Fig. C-42 E81U

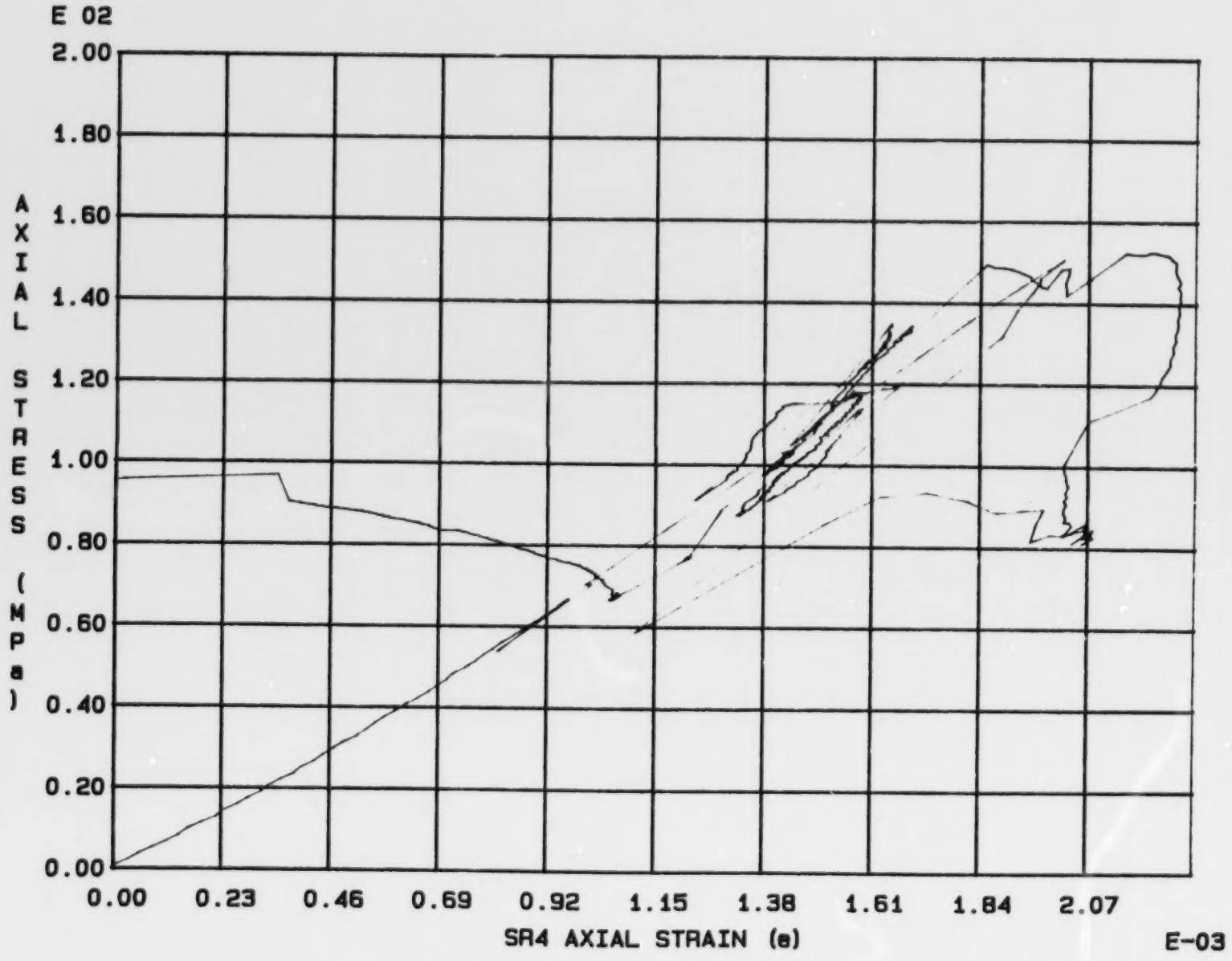

E 02
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
AXIAL STRESS (MPa)
0.00
0.23
0.46
0.69
0.92
1.15
1.38
1.61
1.84
2.07
SR4 AXIAL STRAIN (e)
E-03

Fig. C-43 E82U

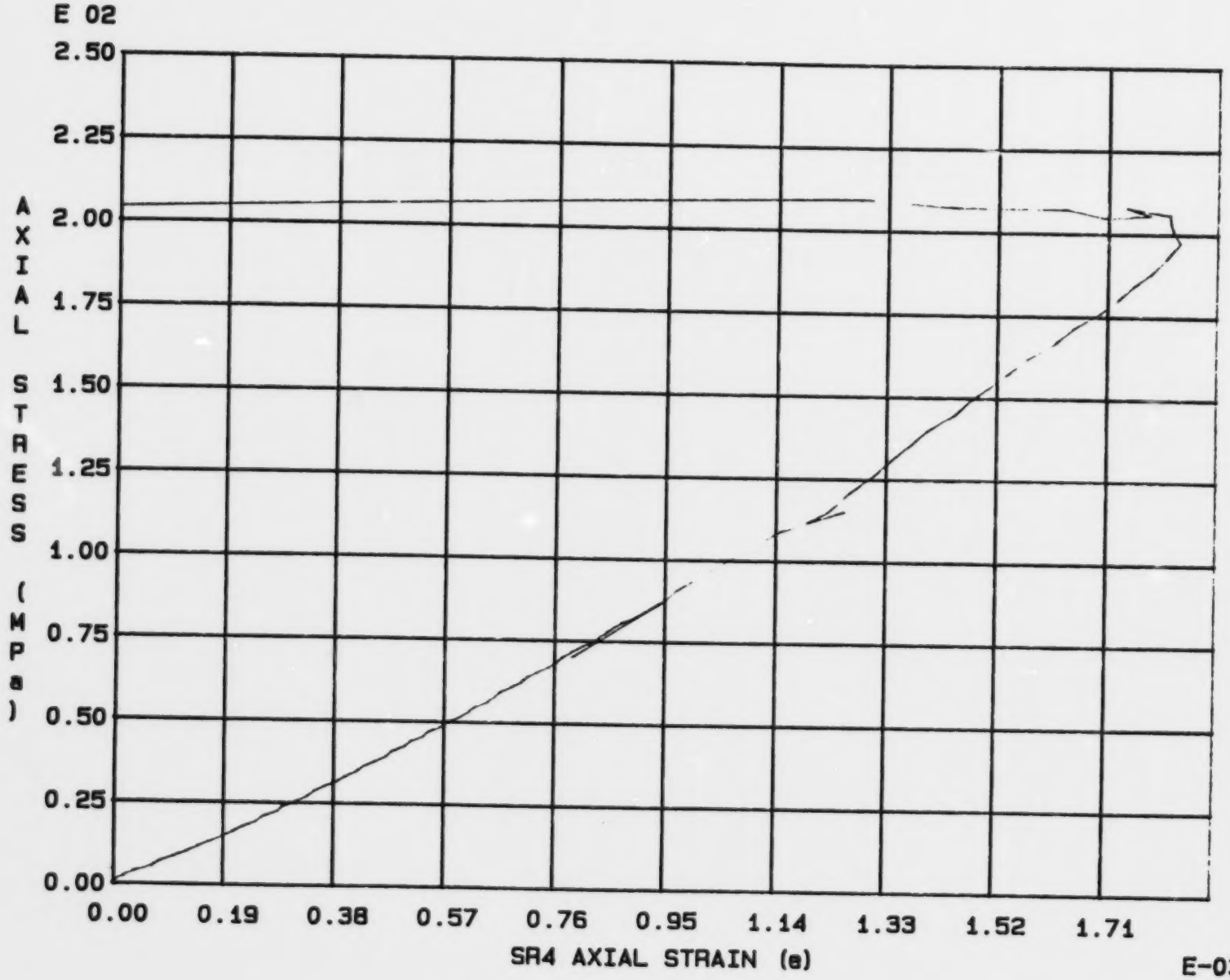

E 02
2.50
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
AXIAL STRESS (MPa)
0.00
0.19
0.38
0.57
0.76
0.95
1.14
1.33
1.52
1.71
SR4 AXIAL STRAIN (e)
E-03

Fig. C-44 E83U

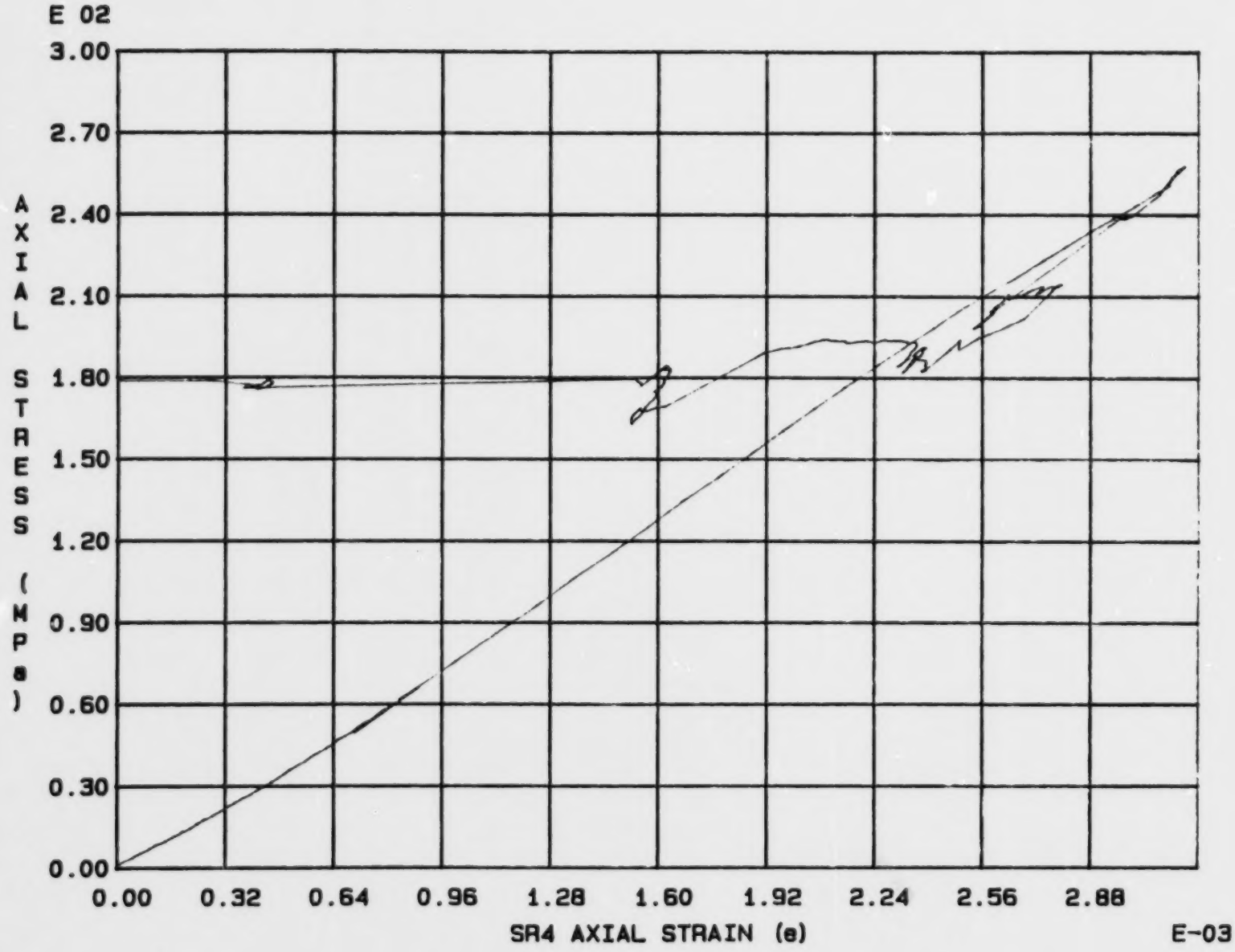

E 02
3.00
2.70
2.40
2.10
1.80
1.50
1.20
0.90
0.60
0.30
0.00
AXIAL STRESS (MPa)
0.00
0.32
0.64
0.96
1.28
1.60
1.92
2.24
2.56
2.88
SR4 AXIAL STRAIN (e)
E-03

Fig. C-45 E84U

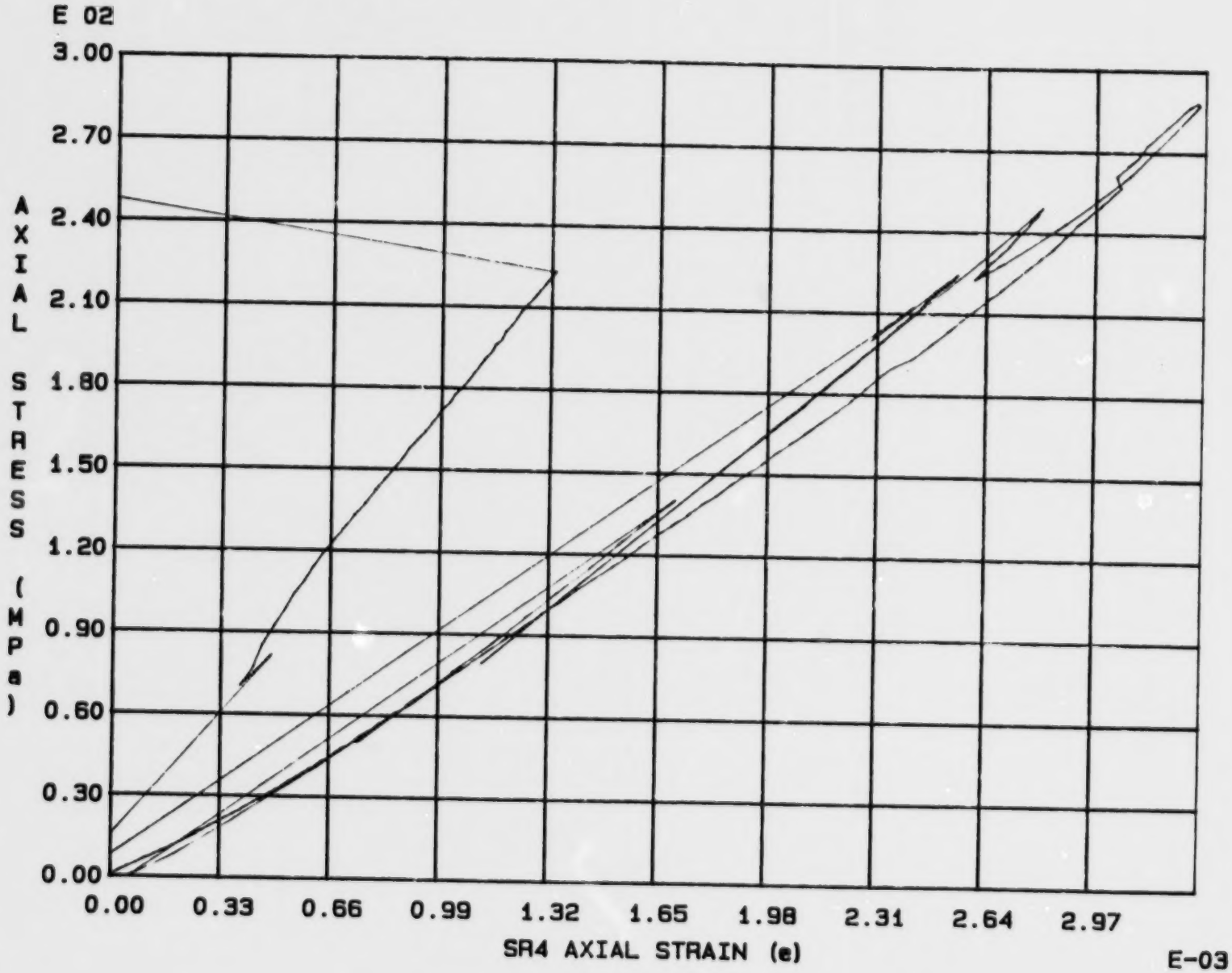

E 02
3.00
2.70
2.40
2.10
1.80
1.50
1.20
0.90
0.60
0.30
0.00
AXIAL STRESS (MPa)
0.00
0.33
0.66
0.99
1.32
1.65
1.98
2.31
2.64
2.97
SR4 AXIAL STRAIN (e)
E-03

Fig. C-46 E85U

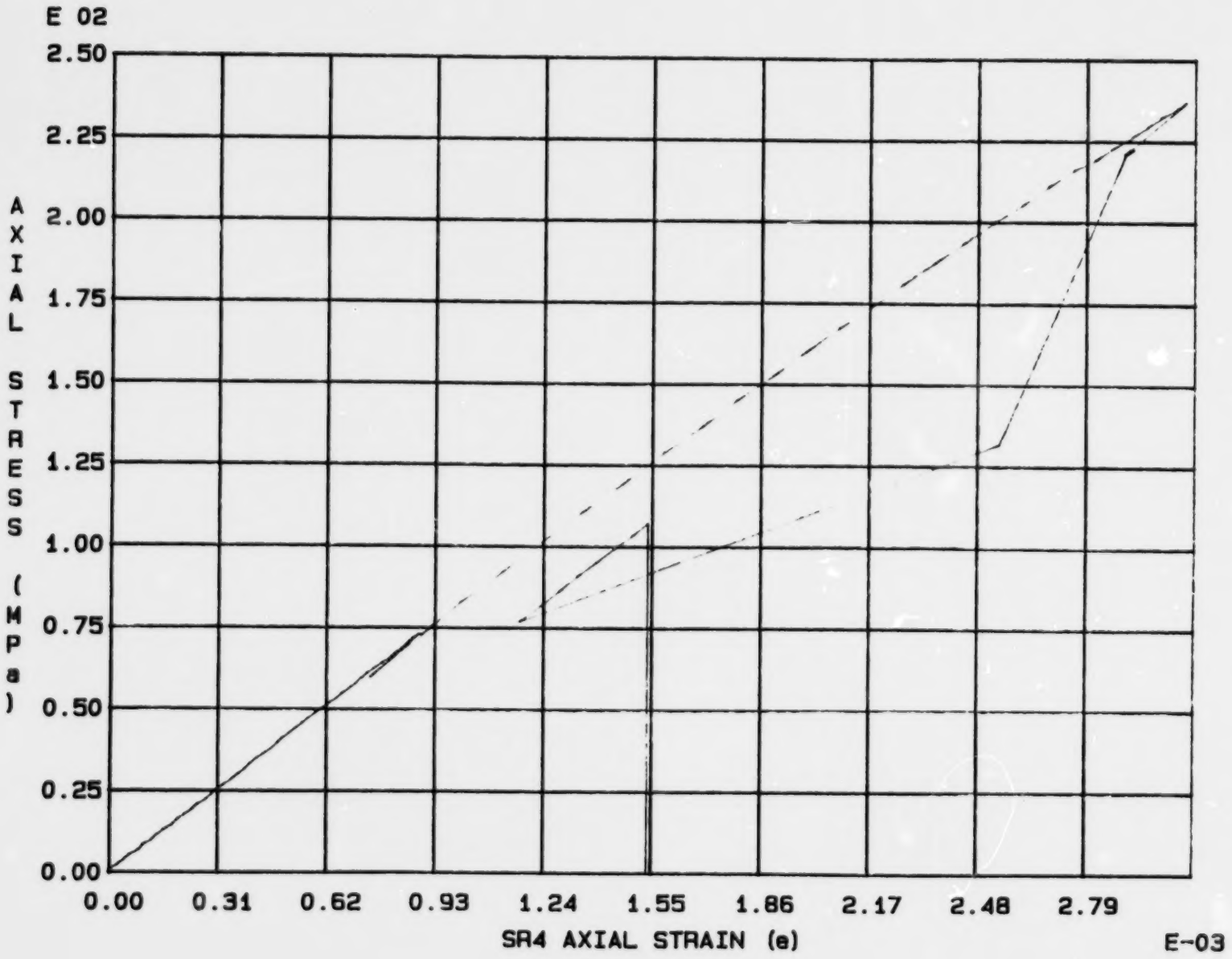

E 02
2.50
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
AXIAL STRESS (MPa)
0.00
0.31
0.62
0.93
1.24
1.55
1.86
2.17
2.48
2.79
SR4 AXIAL STRAIN (e)
E-03

Fig. C-47 E86U

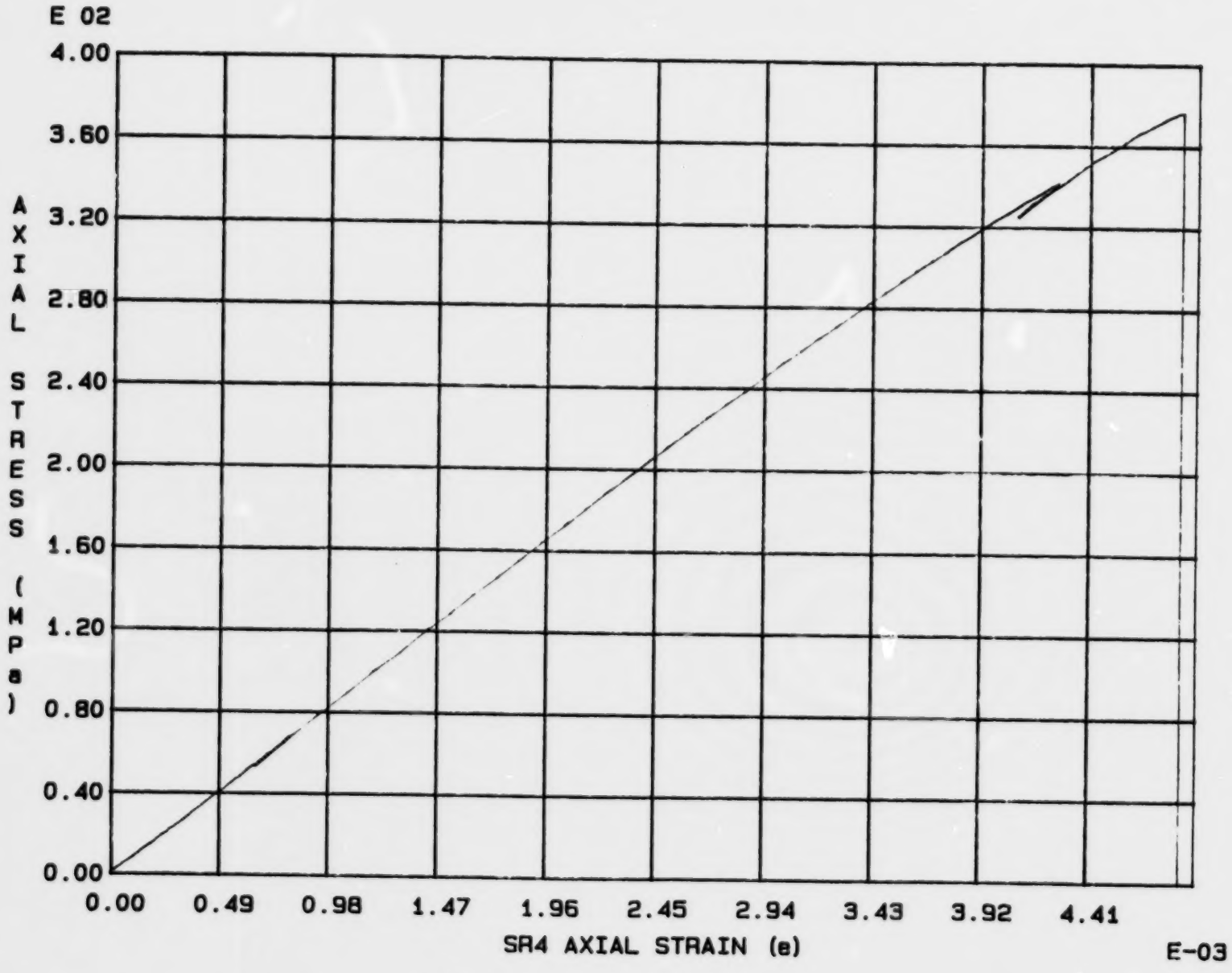

E 02
4.00
3.60
3.20
2.80
2.40
2.00
1.60
1.20
0.80
0.40
0.00
AXIAL STRESS (MPa)
0.00
0.49
0.98
1.47
1.96
2.45
2.94
3.43
3.92
4.41
SR4 AXIAL STRAIN (e)
E-03

Fig. C-48 E87U

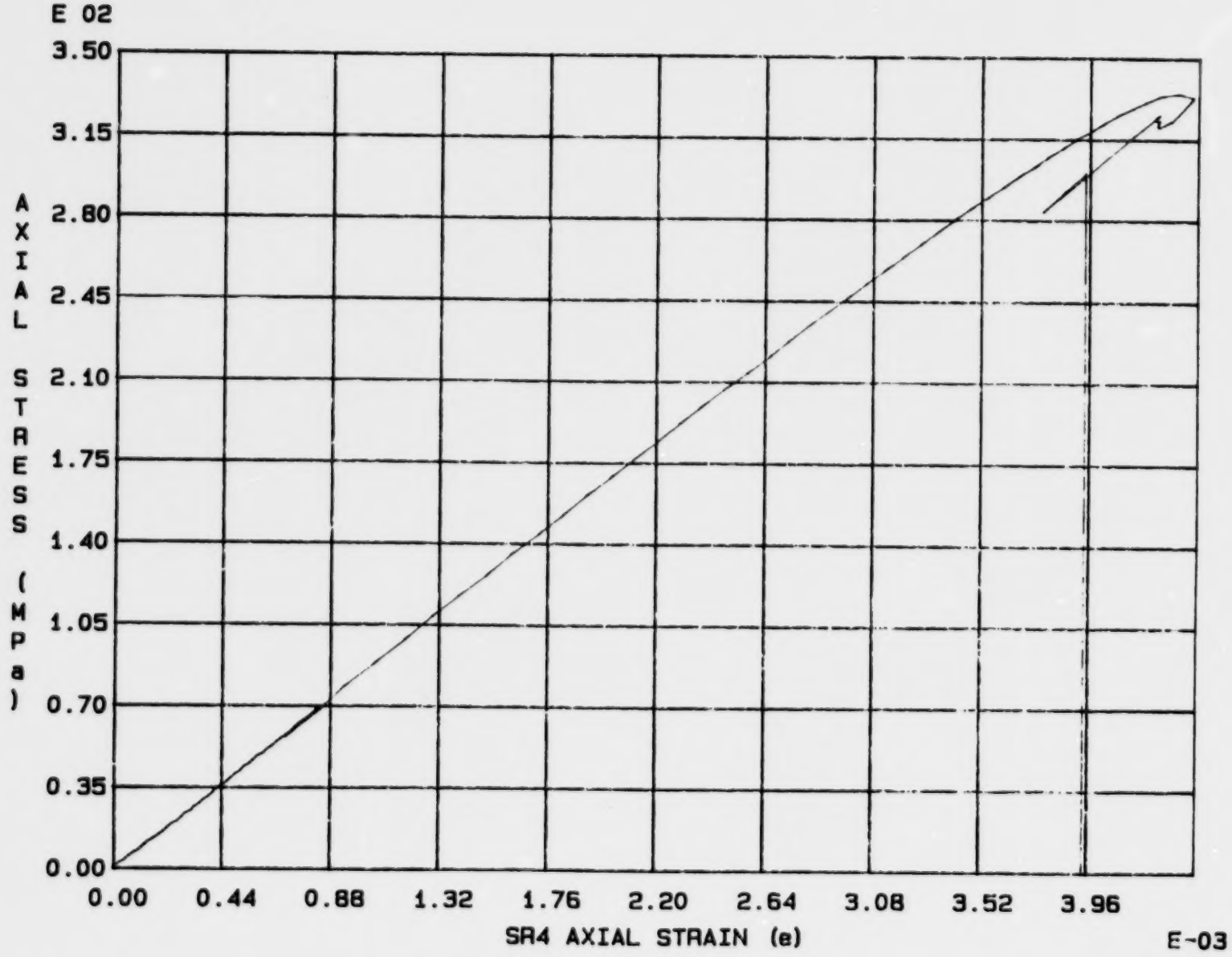

E 02
3.50
3.15
2.80
2.45
2.10
1.75
1.40
1.05
0.70
0.35
0.00
AXIAL STRESS (MPa)
0.00
0.44
0.88
1.32
1.76
2.20
2.64
3.08
3.52
3.96
SR4 AXIAL STRAIN (e)
E-03

Fig. C-49 E88U

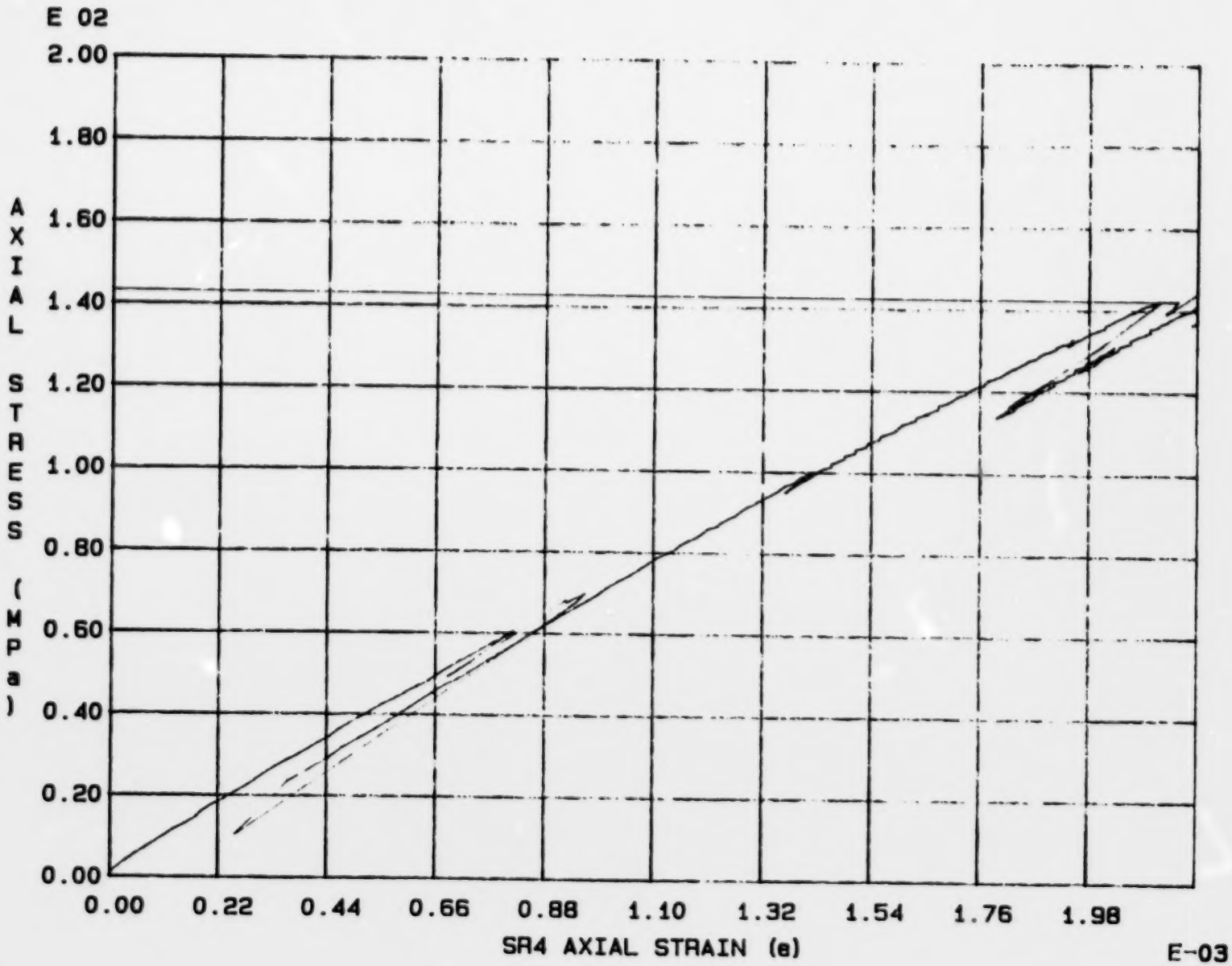

E 02
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
AXIAL STRESS (MPa)
0.00
0.22
0.44
0.66
0.88
1.10
1.32
1.54
1.76
1.98
SR4 AXIAL STRAIN (e)
E-03

Fig. C-50 E89U

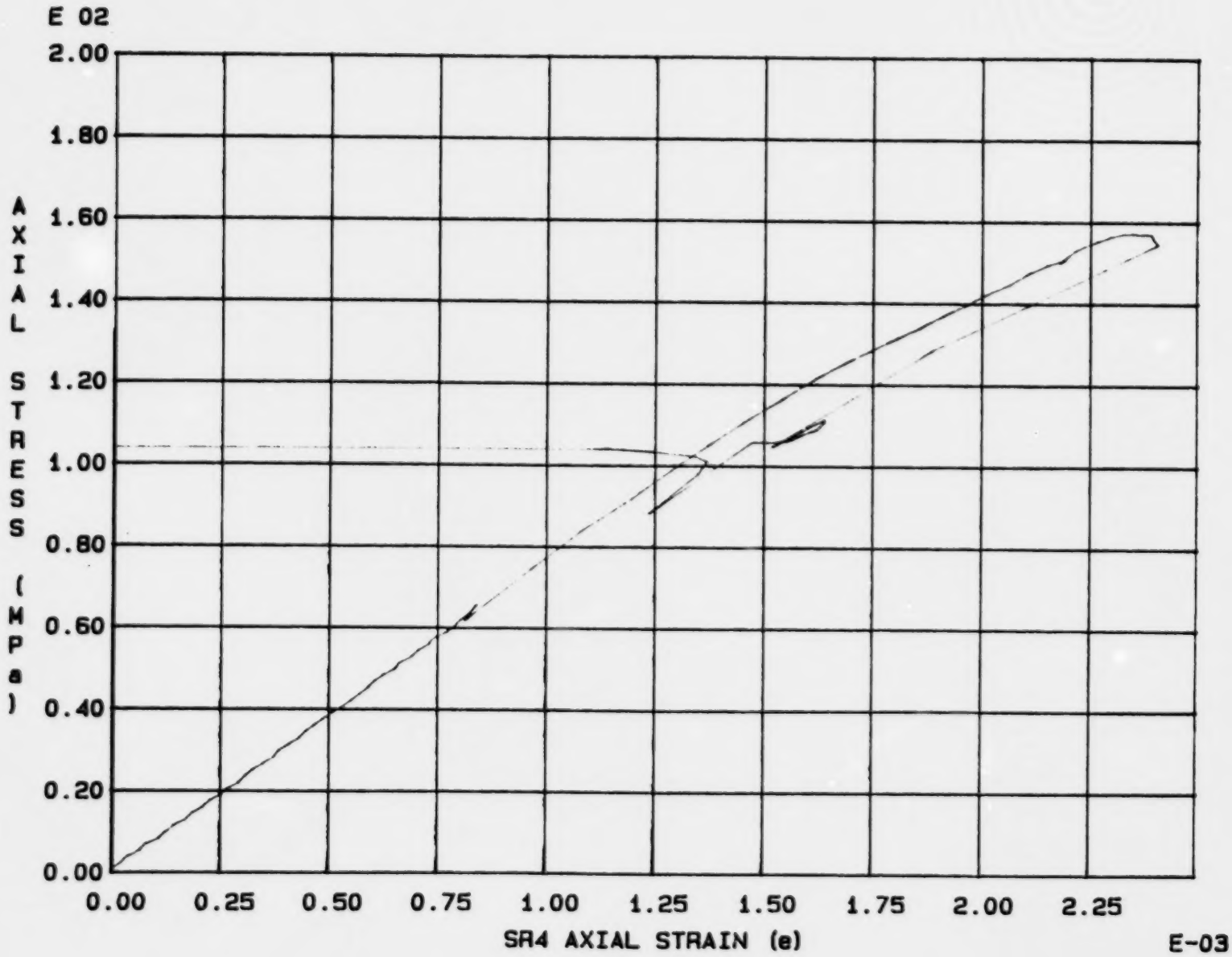

E 02
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
AXIAL STRESS (MPa)
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00
2.25
SR4 AXIAL STRAIN (e)
E-03

Fig. C-51 E90U

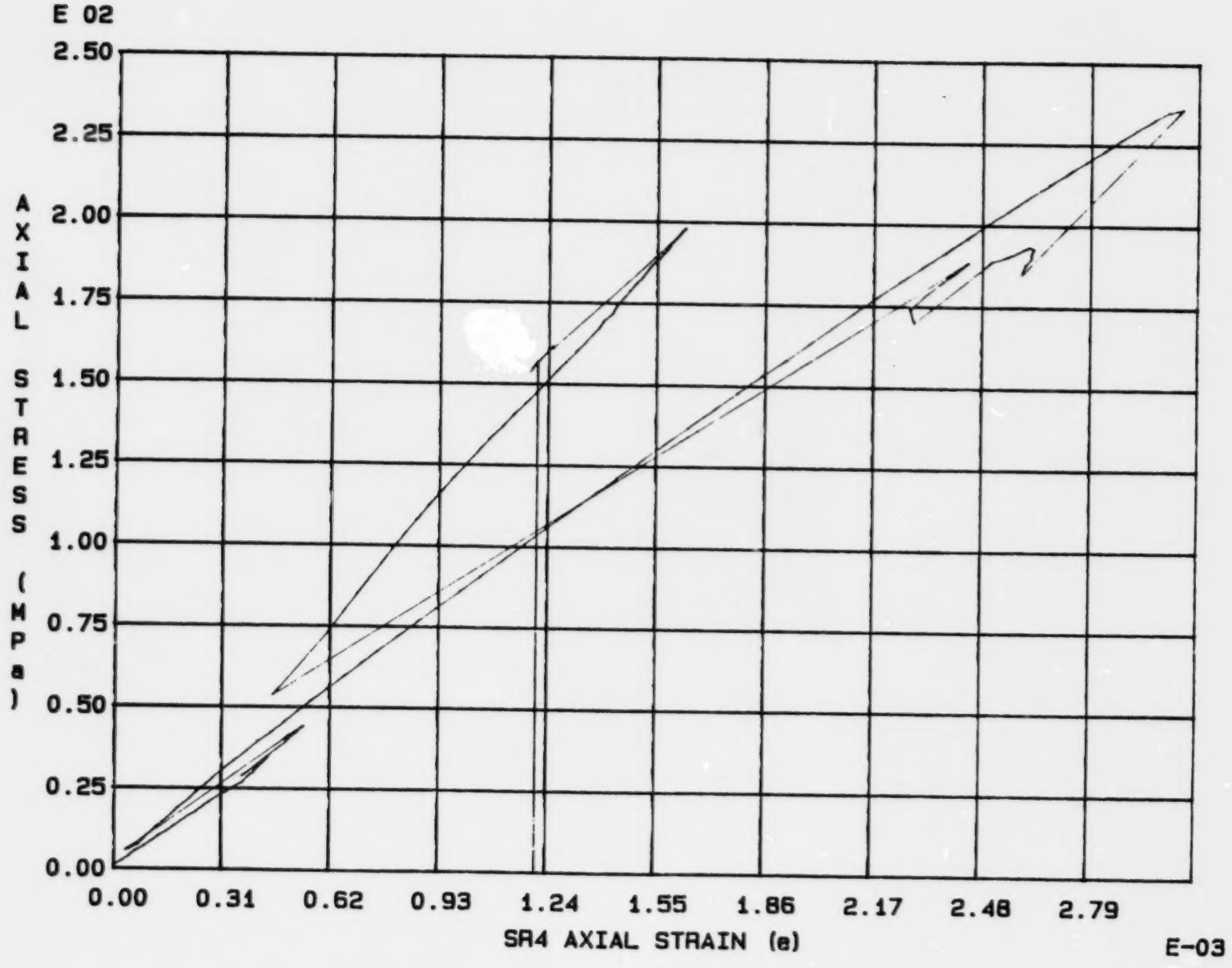

E 02
2.50
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
AXIAL STRESS (MPa)
0.00
0.31
0.62
0.93
1.24
1.55
1.86
2.17
2.48
2.79
SR4 AXIAL STRAIN (e)
E-03

Fig. C-52 E91U

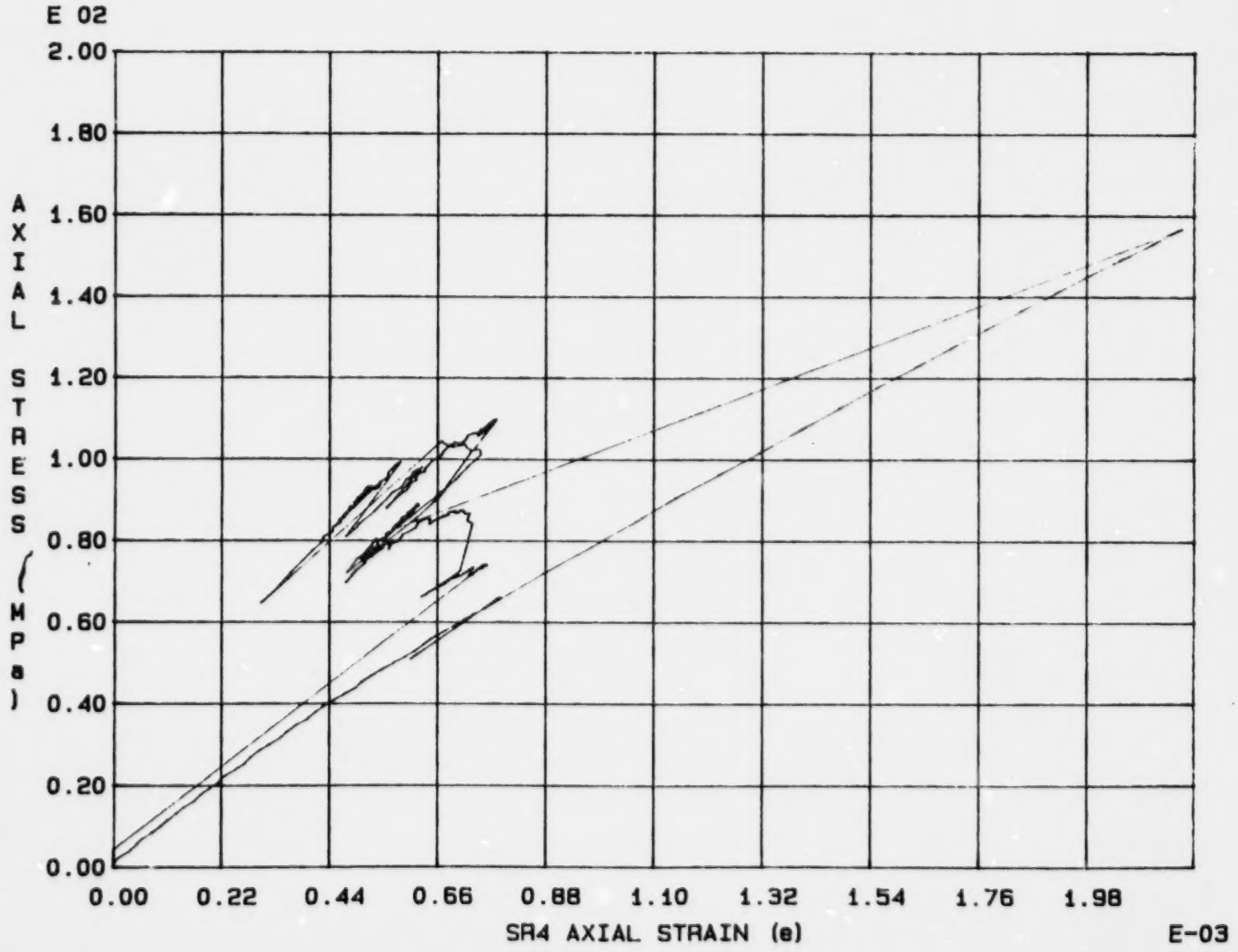


Fig. C-53 E103U

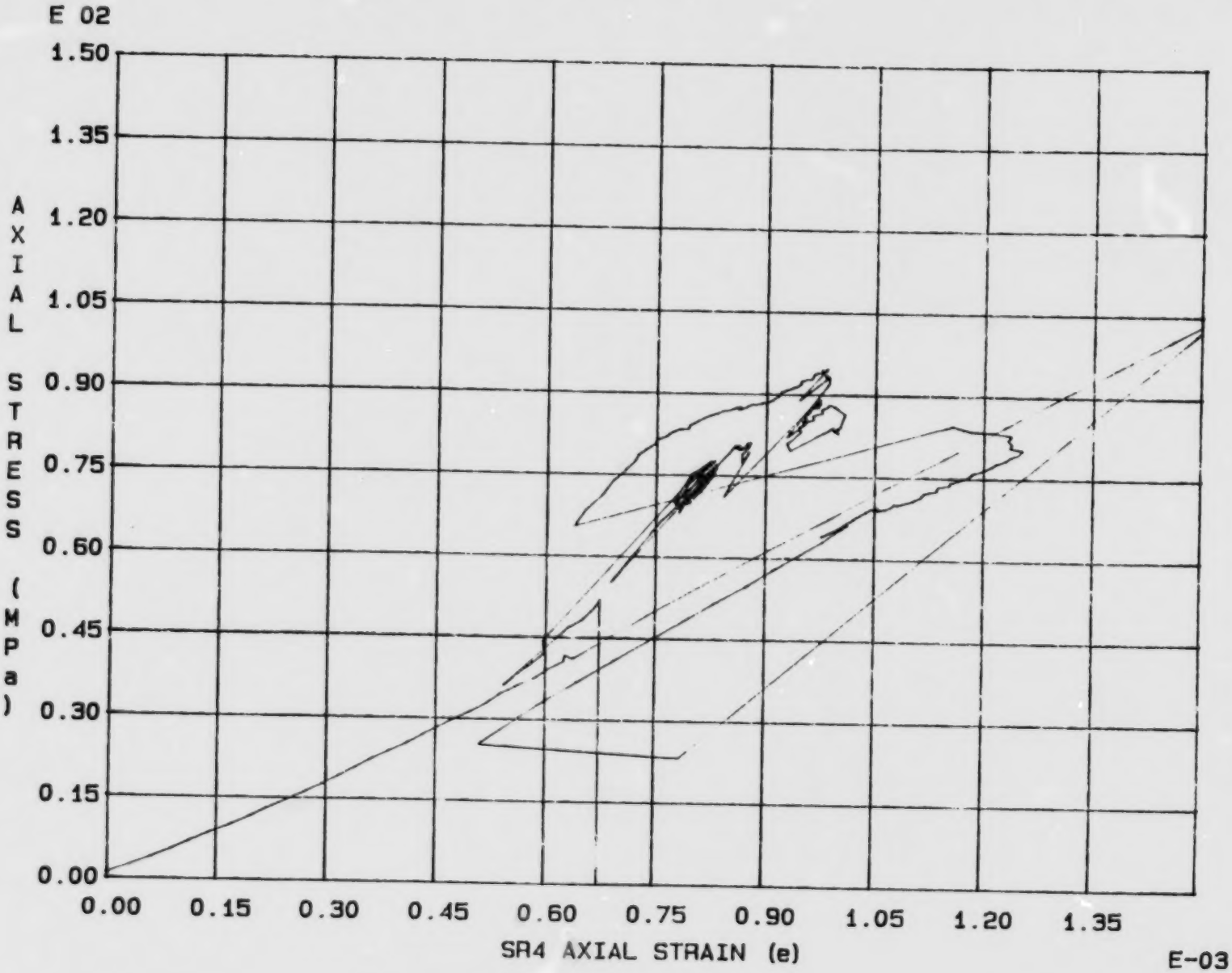


Fig. C-54 E104U

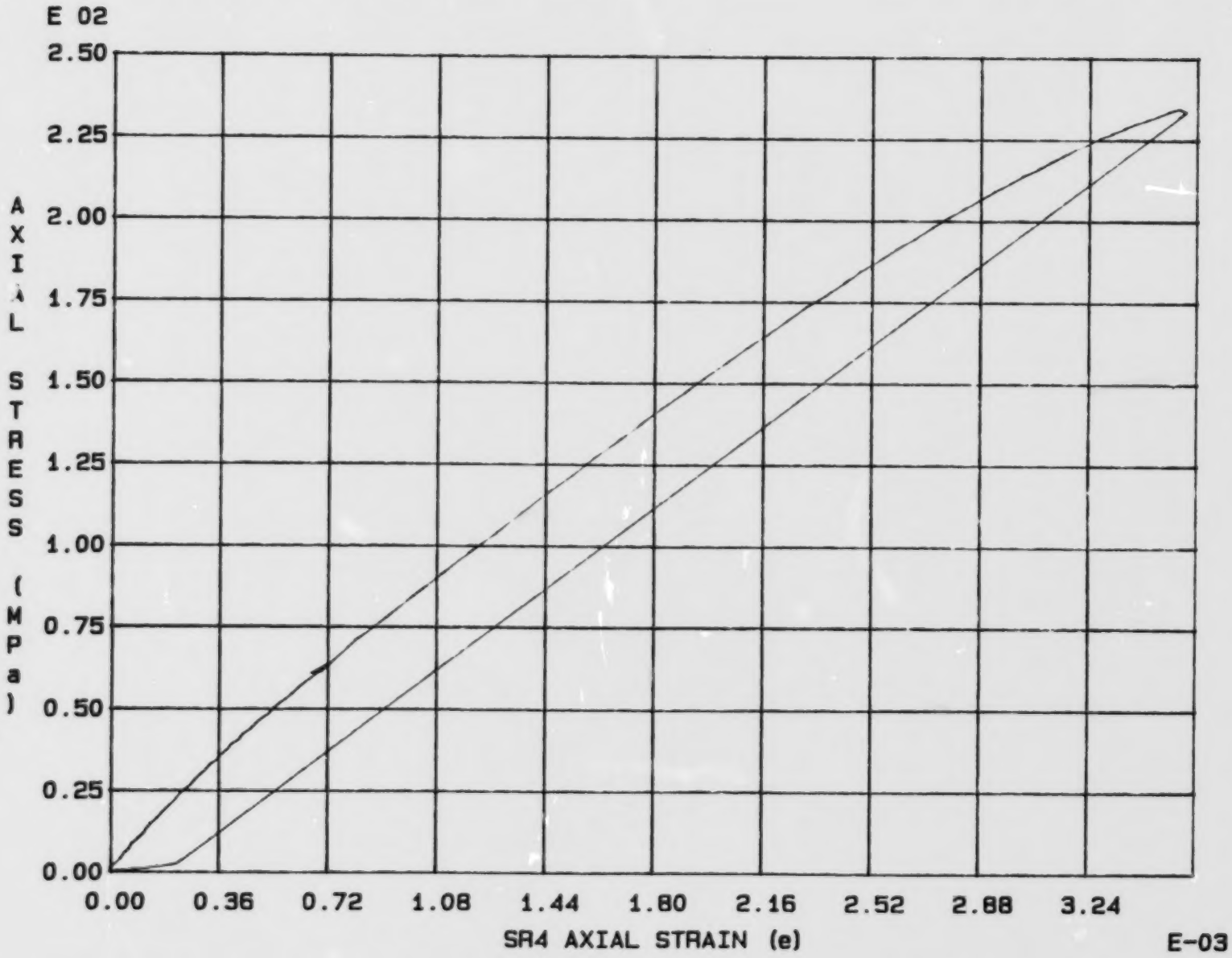


Fig. C-55 E105U

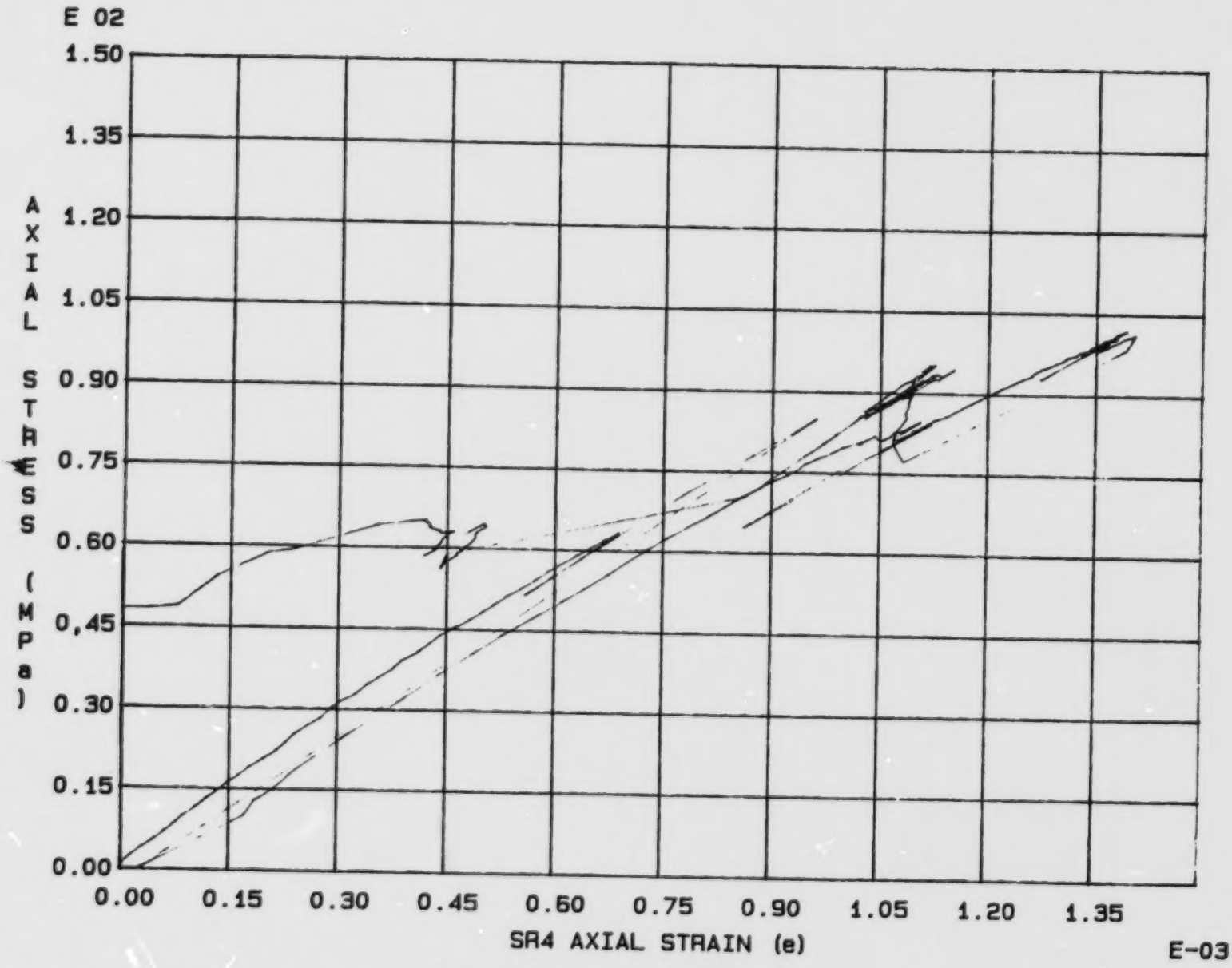


Fig. C-56 E106U

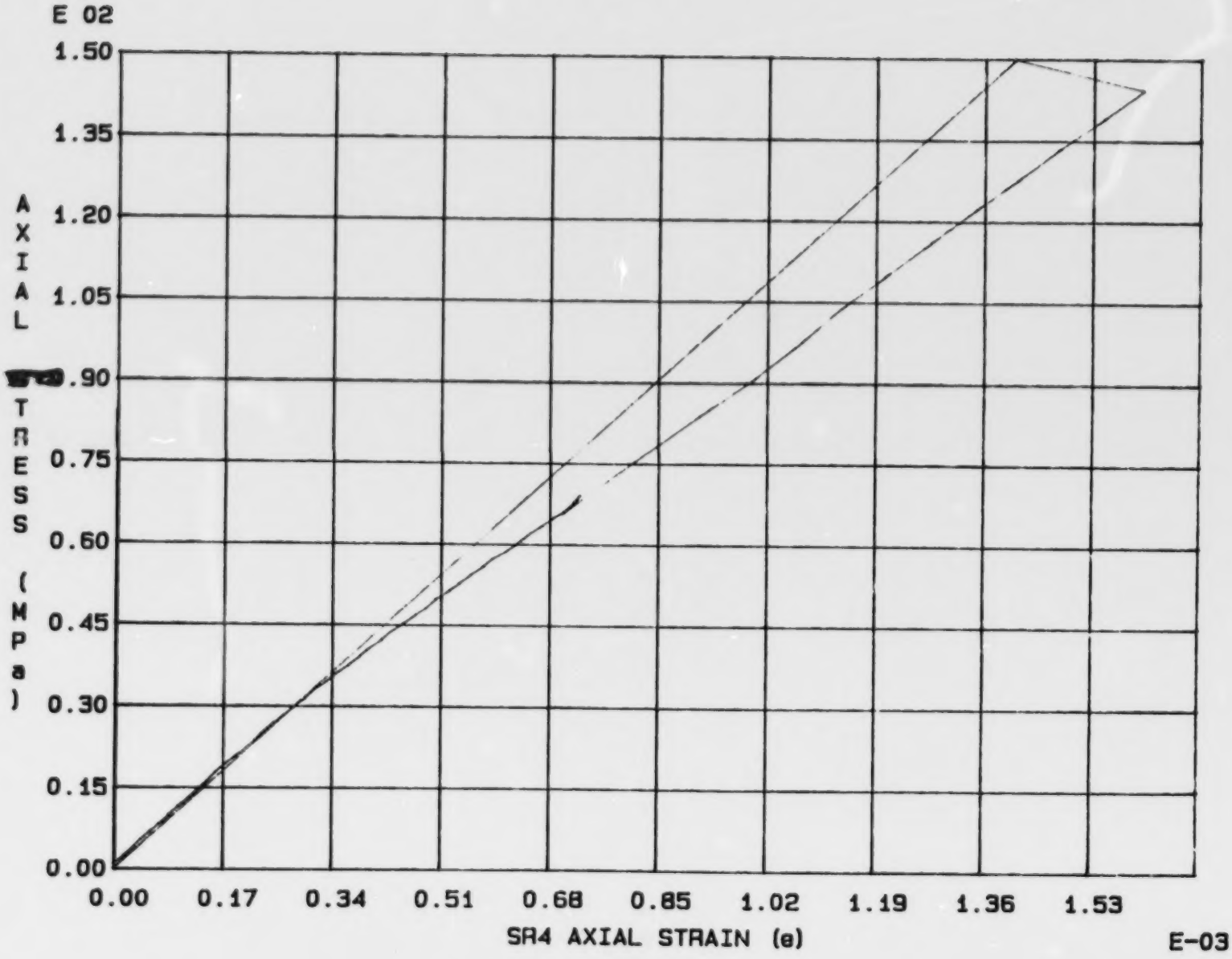


Fig. C-57 E107U

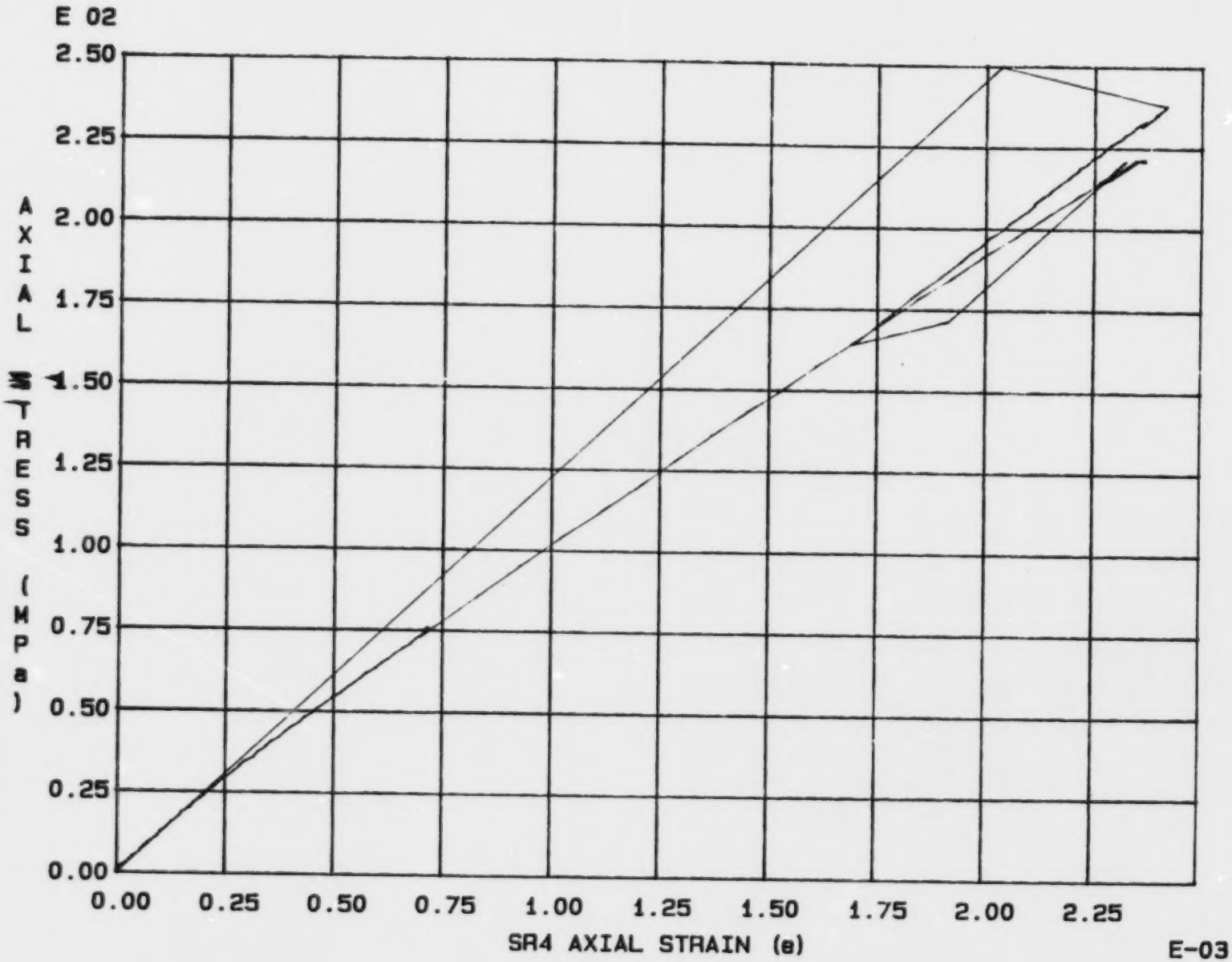


Fig. C-58 E108U

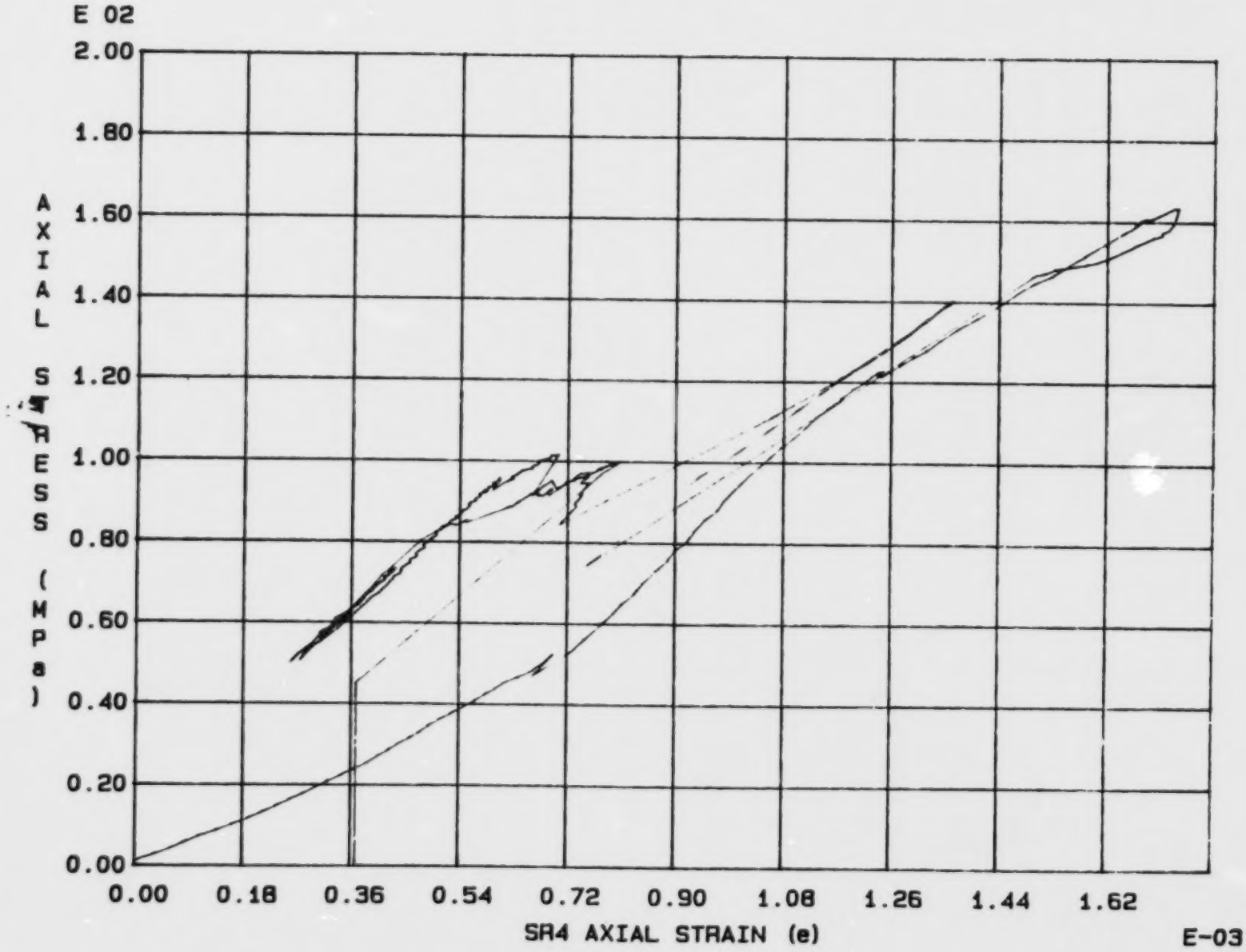


Fig. C-59 E109U

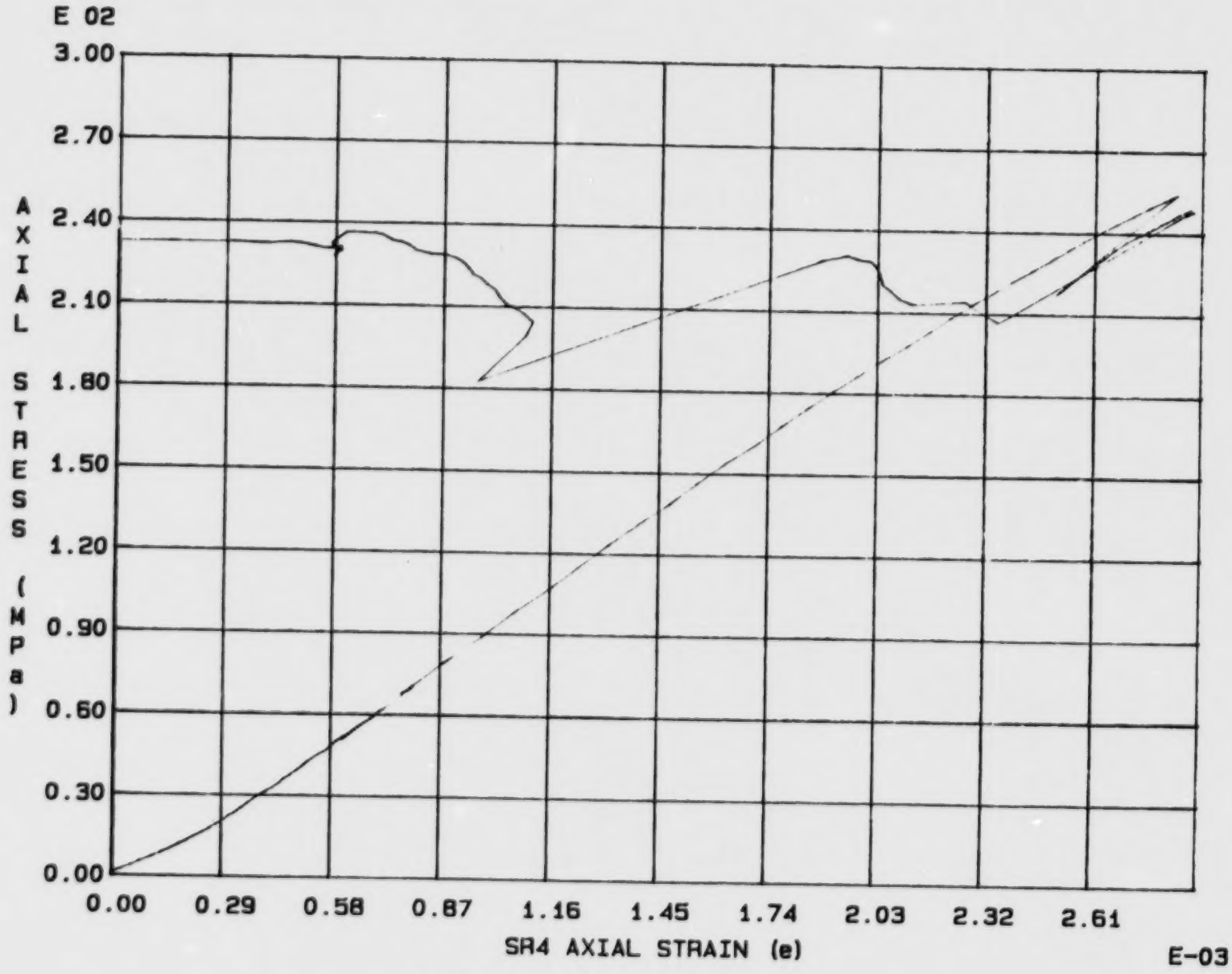


Fig. C-60 E110U

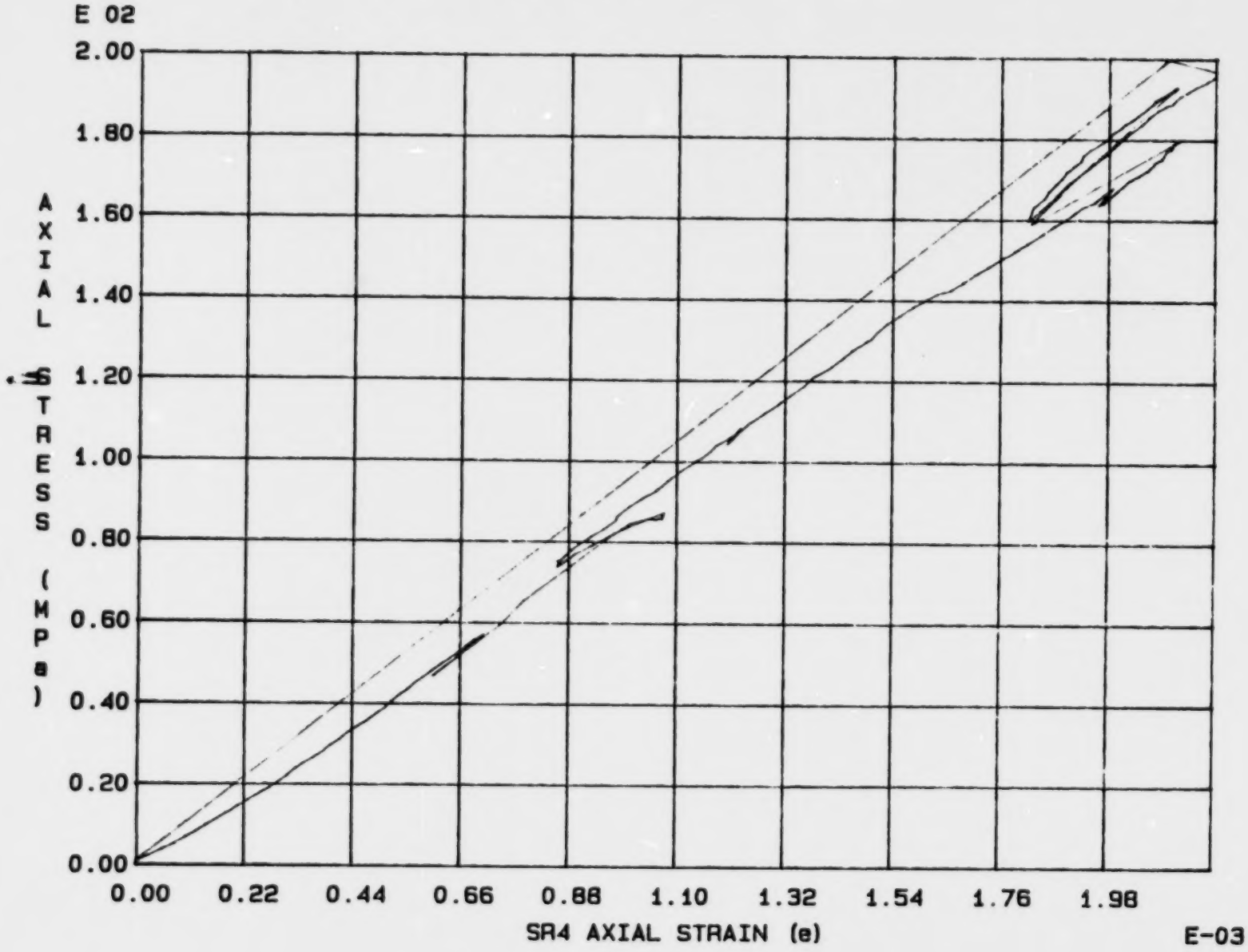


Fig. C-61 E111U

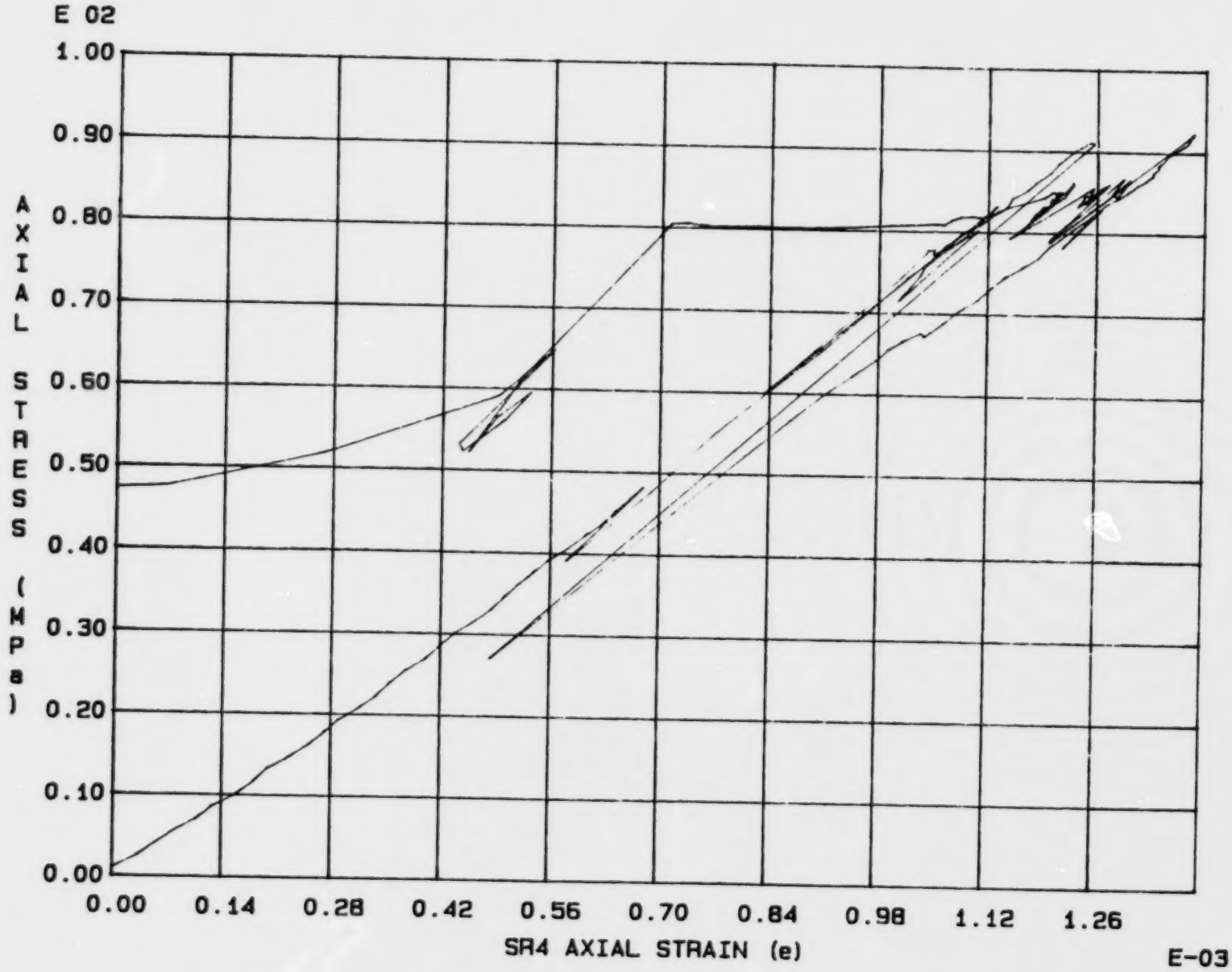


Fig. C-62 E112U

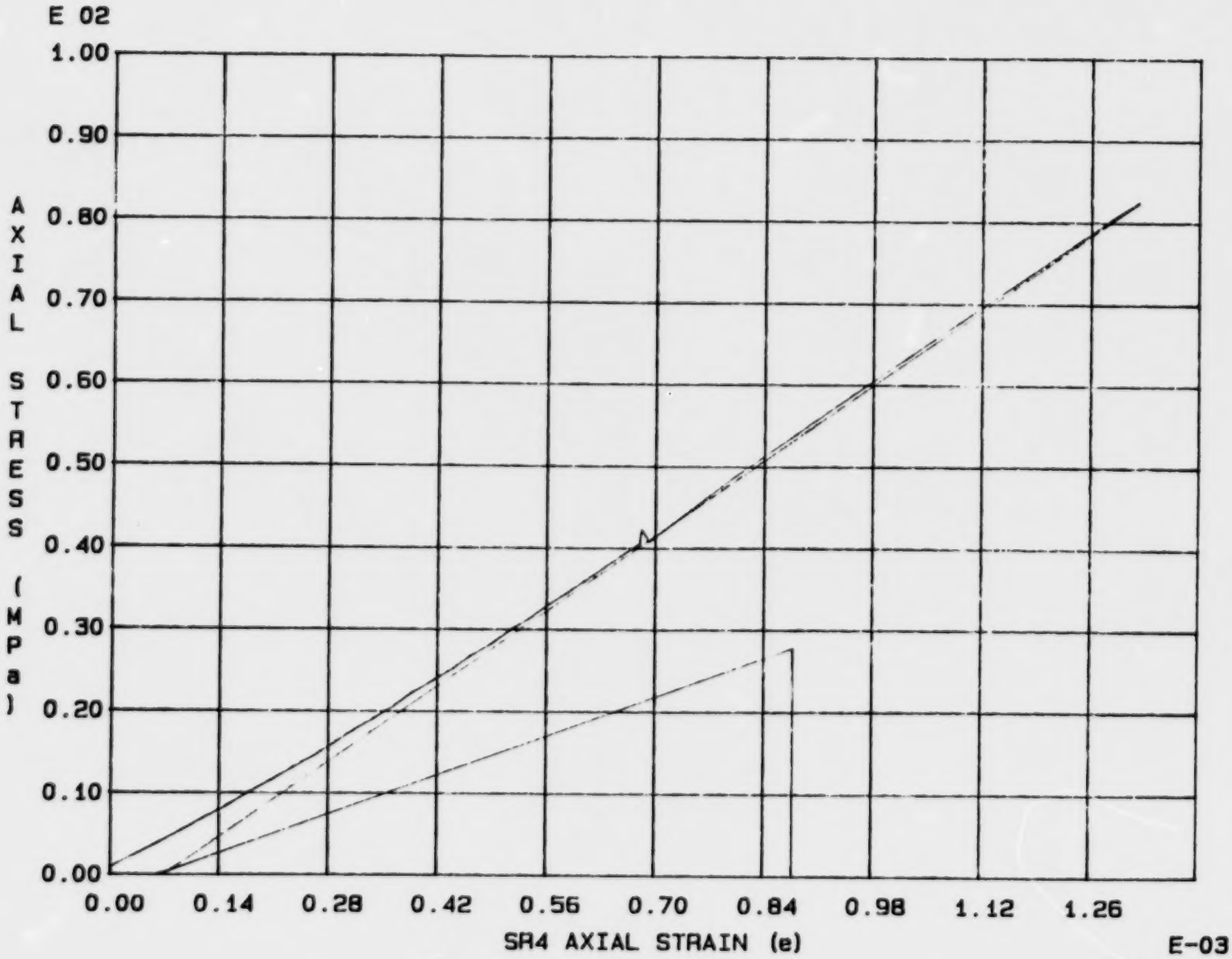


Fig. C-63 E113U

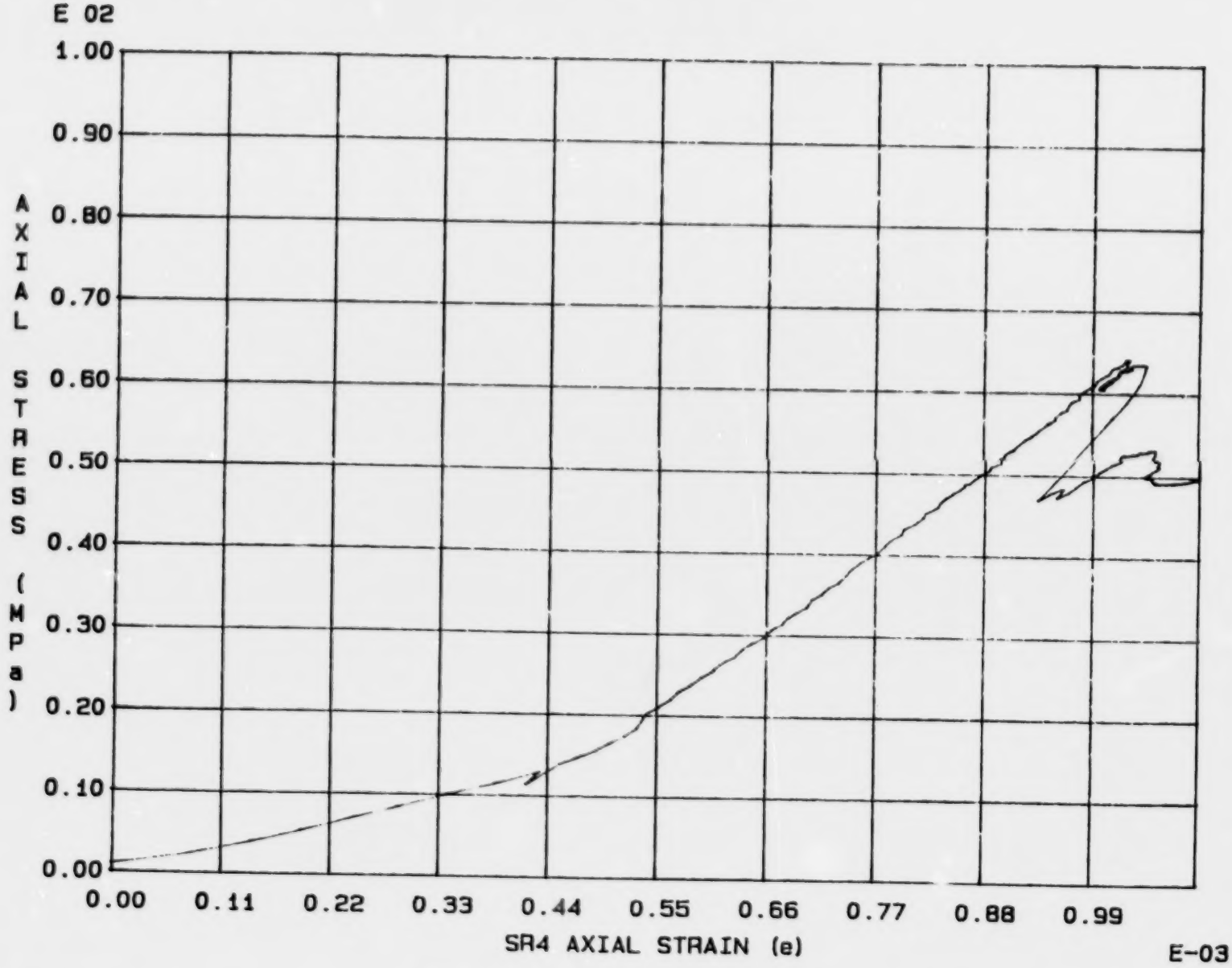


Fig. C-64 E114U

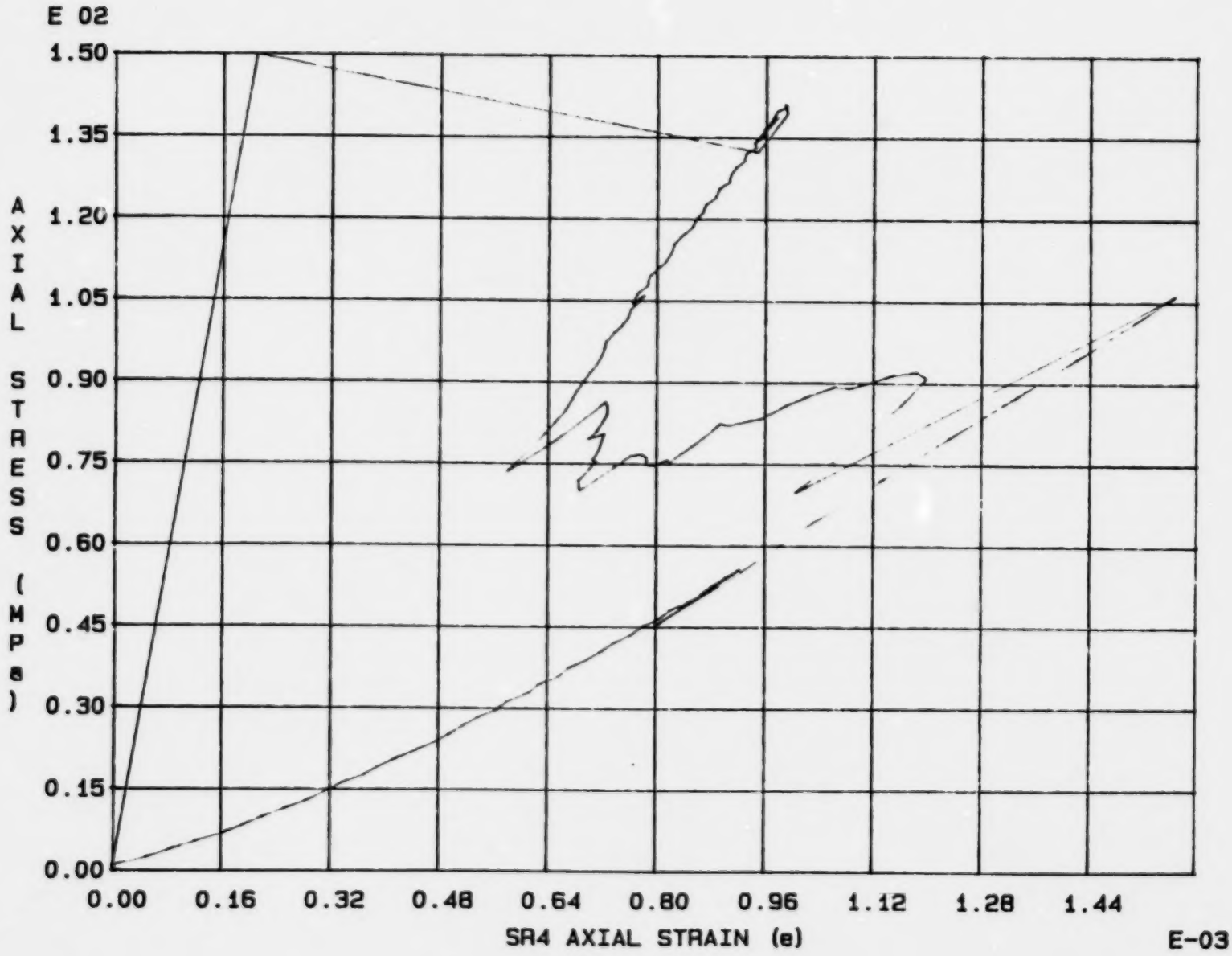


Fig. C-65 E115U

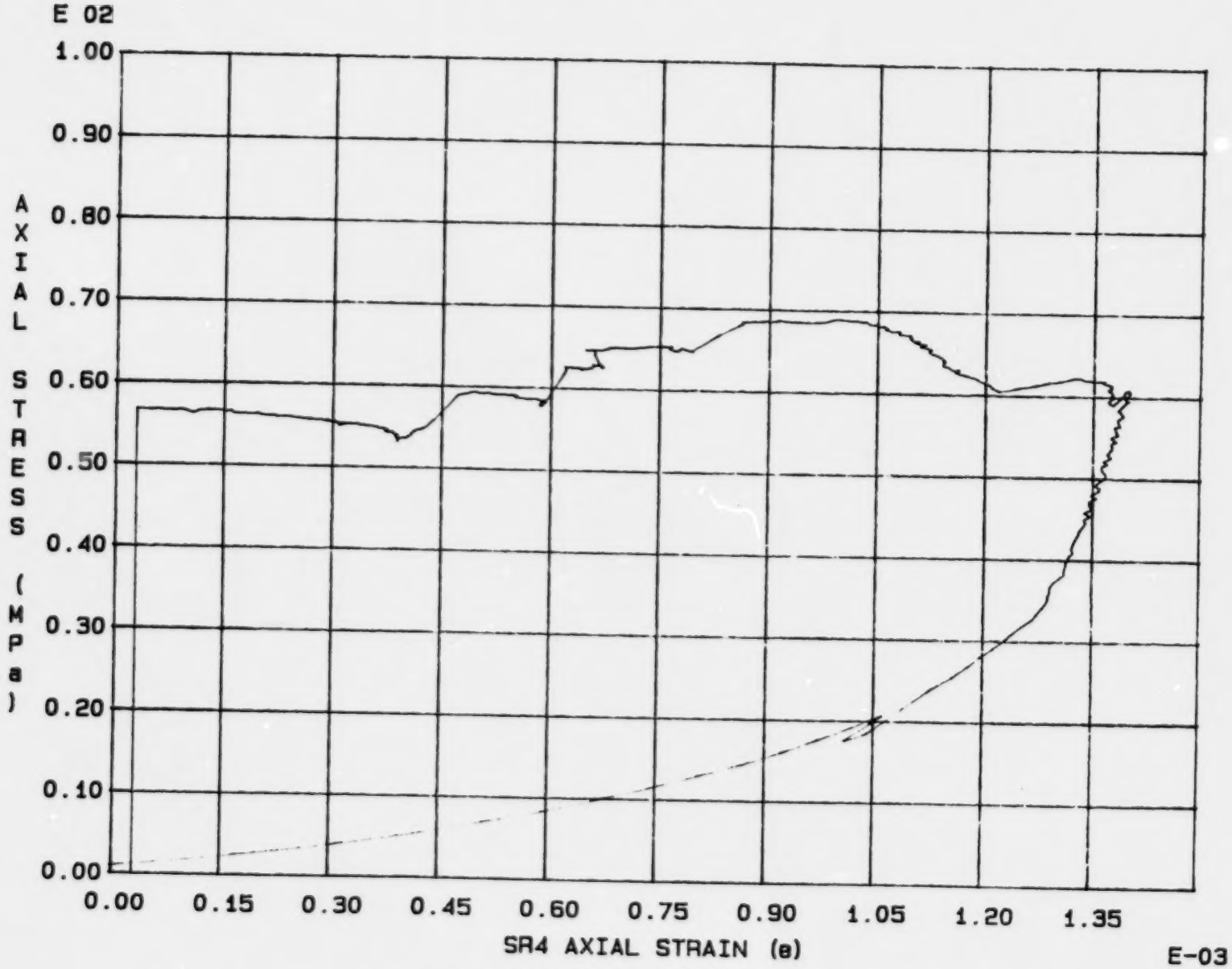


Fig. C-66 E116U

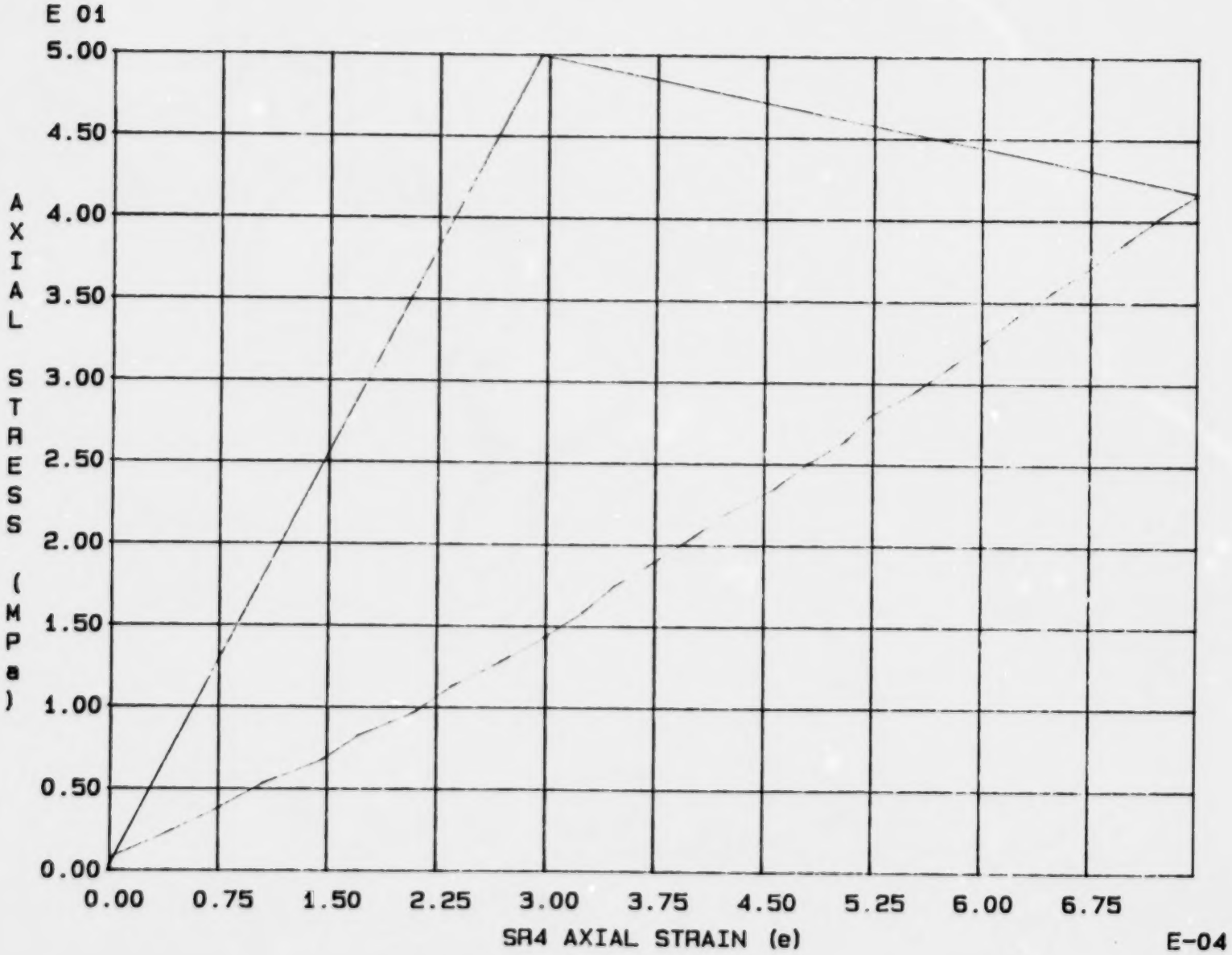


Fig. C-67 E117U

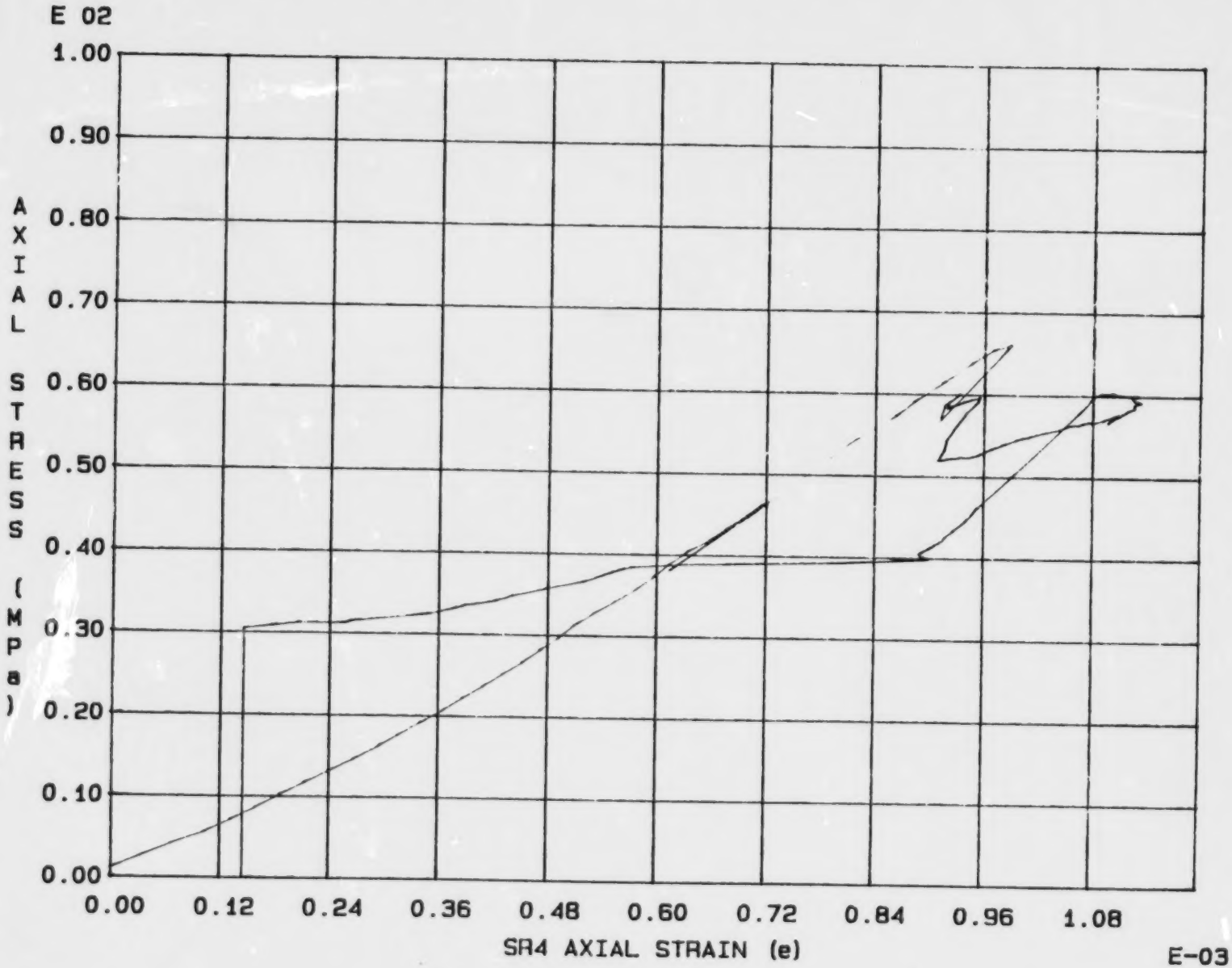


Fig. C-68 E118U

APPENDIX D

STRESS-STRAIN CURVES OF UNIAXIAL TESTS USING CIRCUMFERENTIAL STRAIN GAUGES

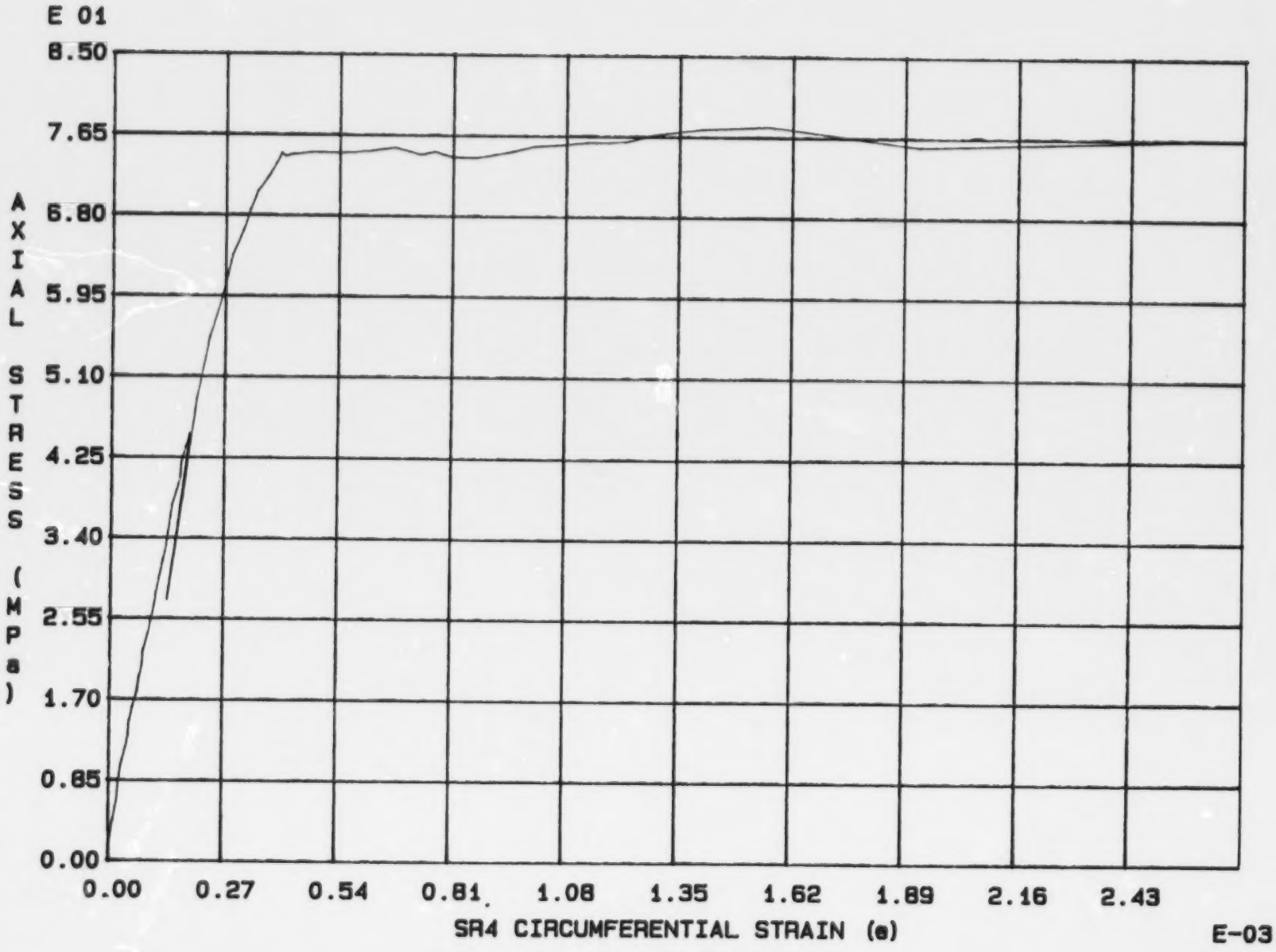

E 01
8.50
7.65
6.80
5.95
5.10
4.25
3.40
2.55
1.70
0.85
0.00
AXIAL STRESS (MPa)
0.00
0.27
0.54
0.81
1.08
1.35
1.62
1.89
2.16
2.43
SR4 CIRCUMFERENTIAL STRAIN (e)
E-03

Fig. D-1 E1U

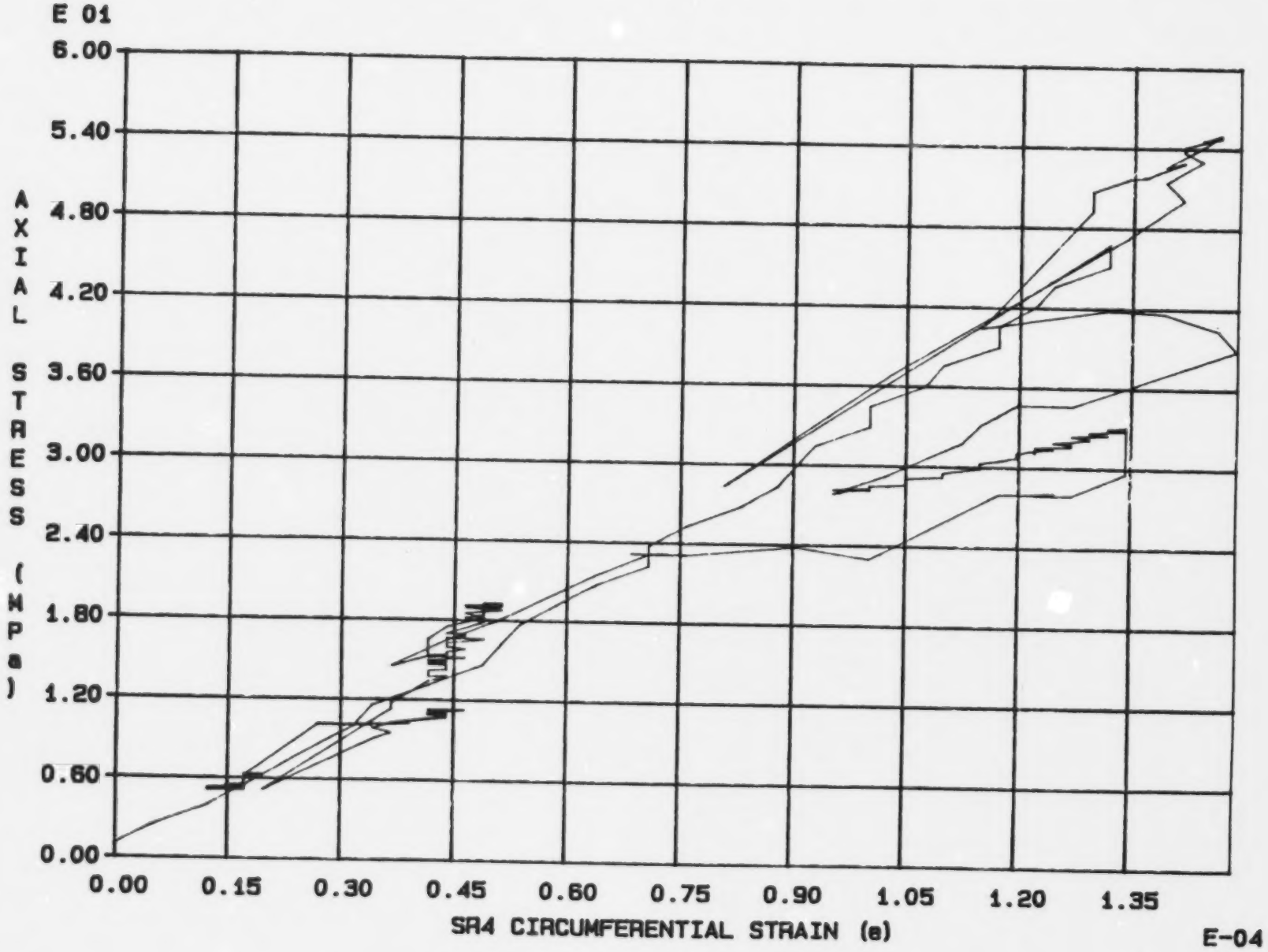

E 01
6.00
5.40
4.80
4.20
3.60
3.00
2.40
1.80
1.20
0.60
0.00
AXIAL STRESS (MPa)
0.00
0.15
0.30
0.45
0.60
0.75
0.90
1.05
1.20
1.35
SR4 CIRCUMFERENTIAL STRAIN (e)
E-04

Fig. D-2 E3U

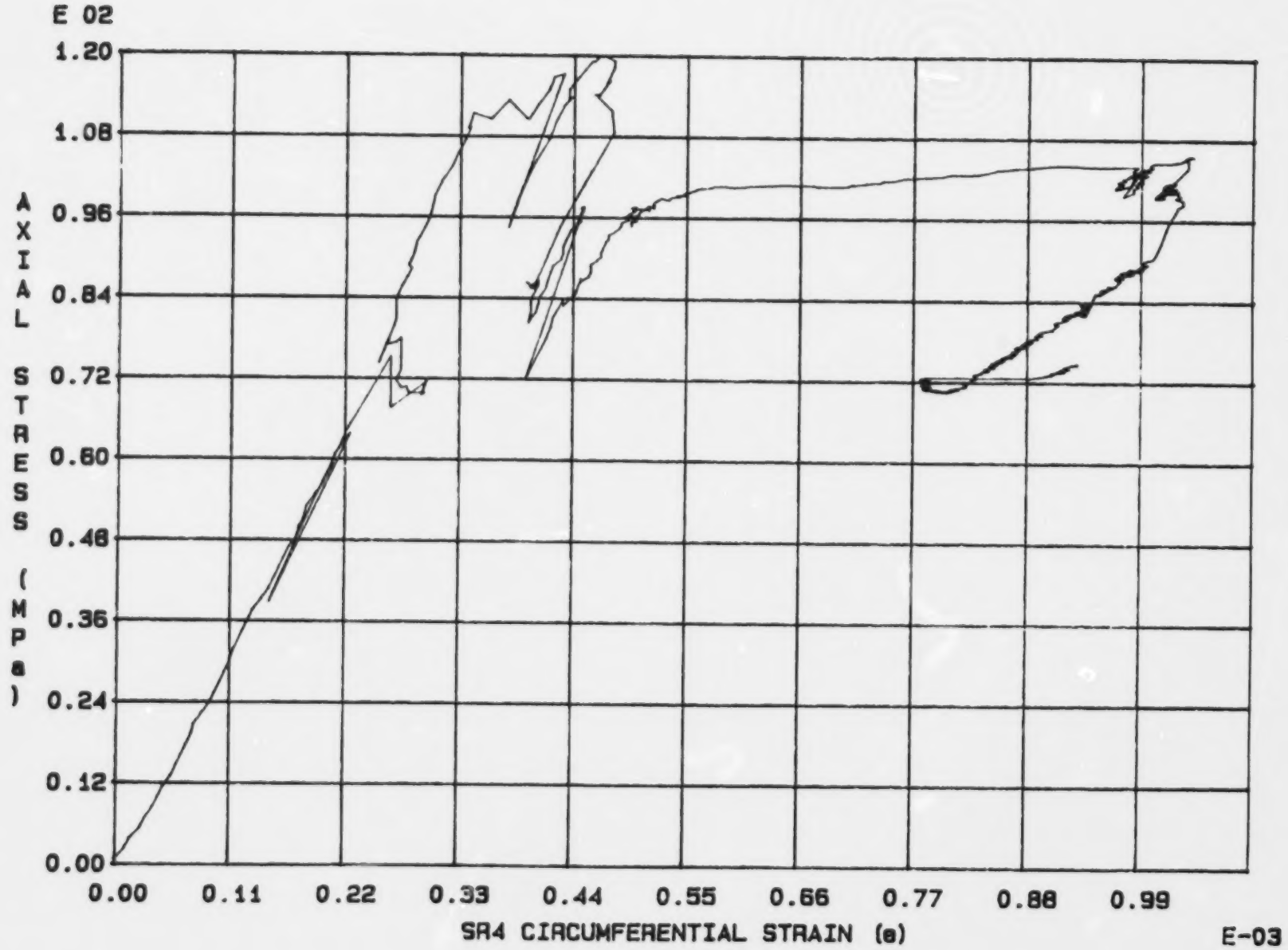

E 02
1.20
1.08
0.96
0.84
0.72
0.60
0.48
0.36
0.24
0.12
0.00
AXIAL STRESS (MPa)
0.00
0.11
0.22
0.33
0.44
0.55
0.66
0.77
0.88
0.99
SR4 CIRCUMFERENTIAL STRAIN (e)
E-03

Fig. D-3 E5U

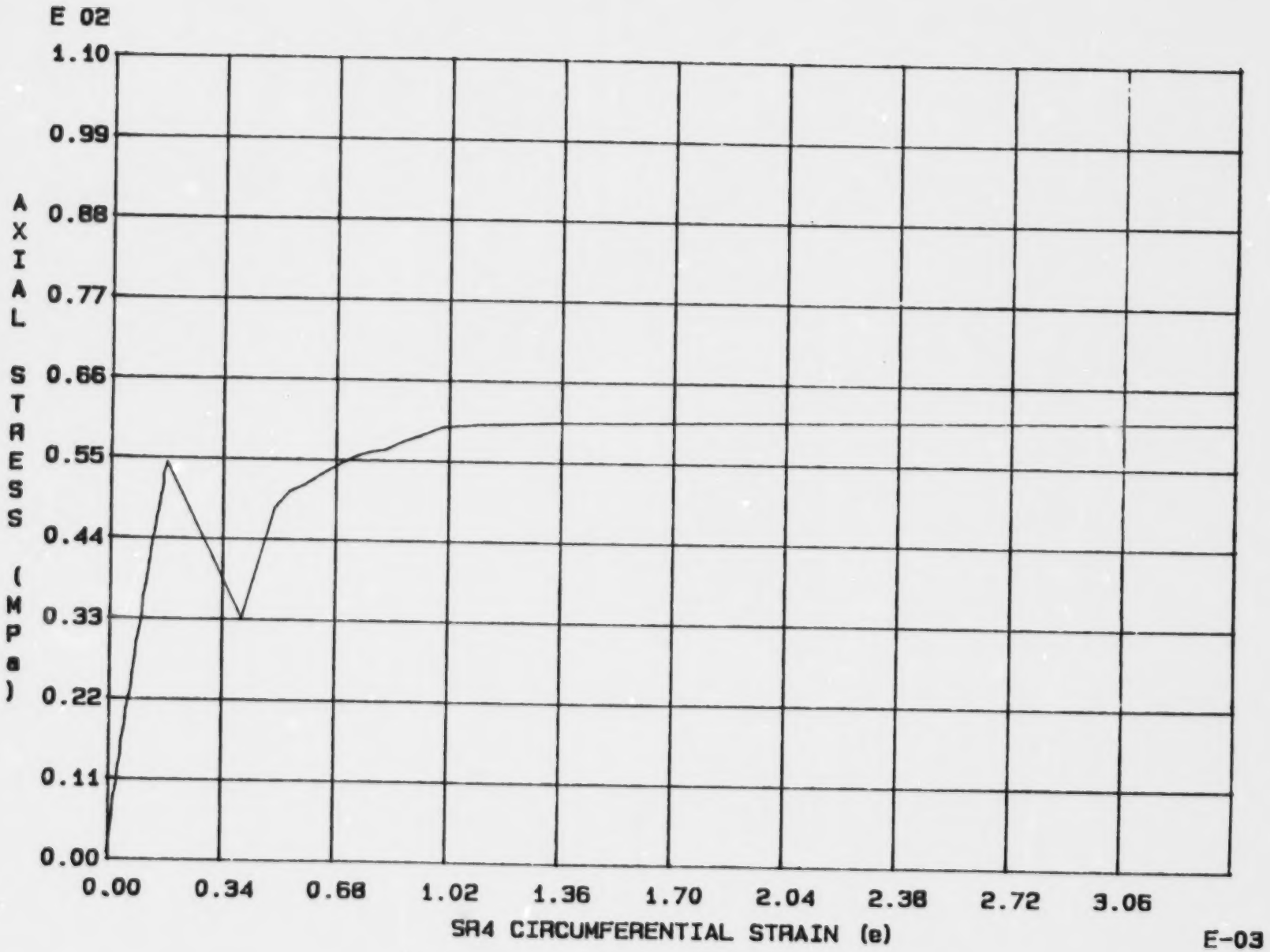

E 02
1.10
0.99
0.88
0.77
0.66
0.55
0.44
0.33
0.22
0.11
0.00
AXIAL STRESS (MPa)
0.00
0.34
0.68
1.02
1.36
1.70
2.04
2.38
2.72
3.06
SR4 CIRCUMFERENTIAL STRAIN (e)
E-03

Fig. D-4 E7U

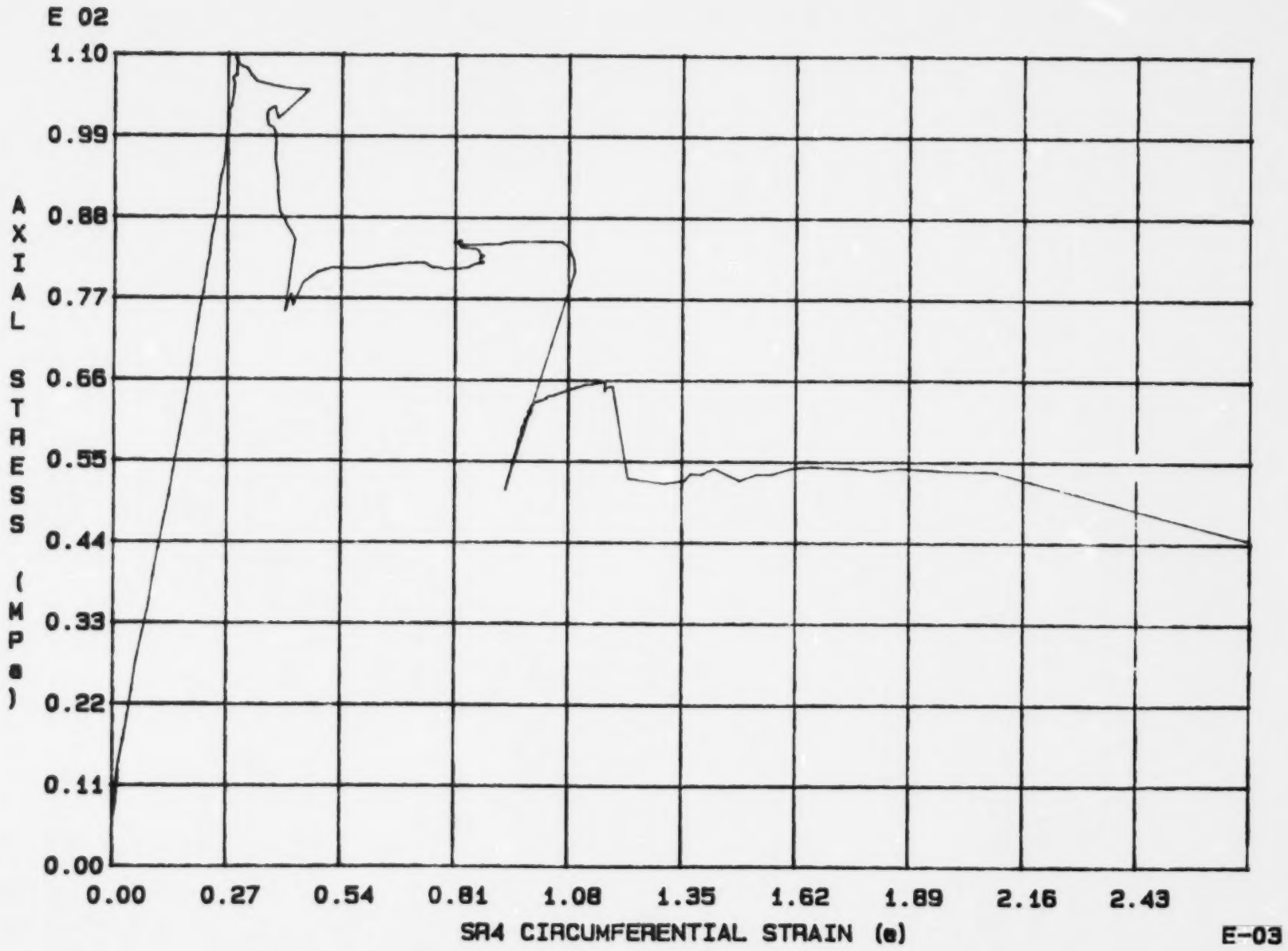

E 02
1.10
0.99
0.88
0.77
0.66
0.55
0.44
0.33
0.22
0.11
0.00
AXIAL STRESS (MPa)
0.00
0.27
0.54
0.81
1.08
1.35
1.62
1.89
2.16
2.43
SR4 CIRCUMFERENTIAL STRAIN (e)
E-03

Fig. D-5 E9UA

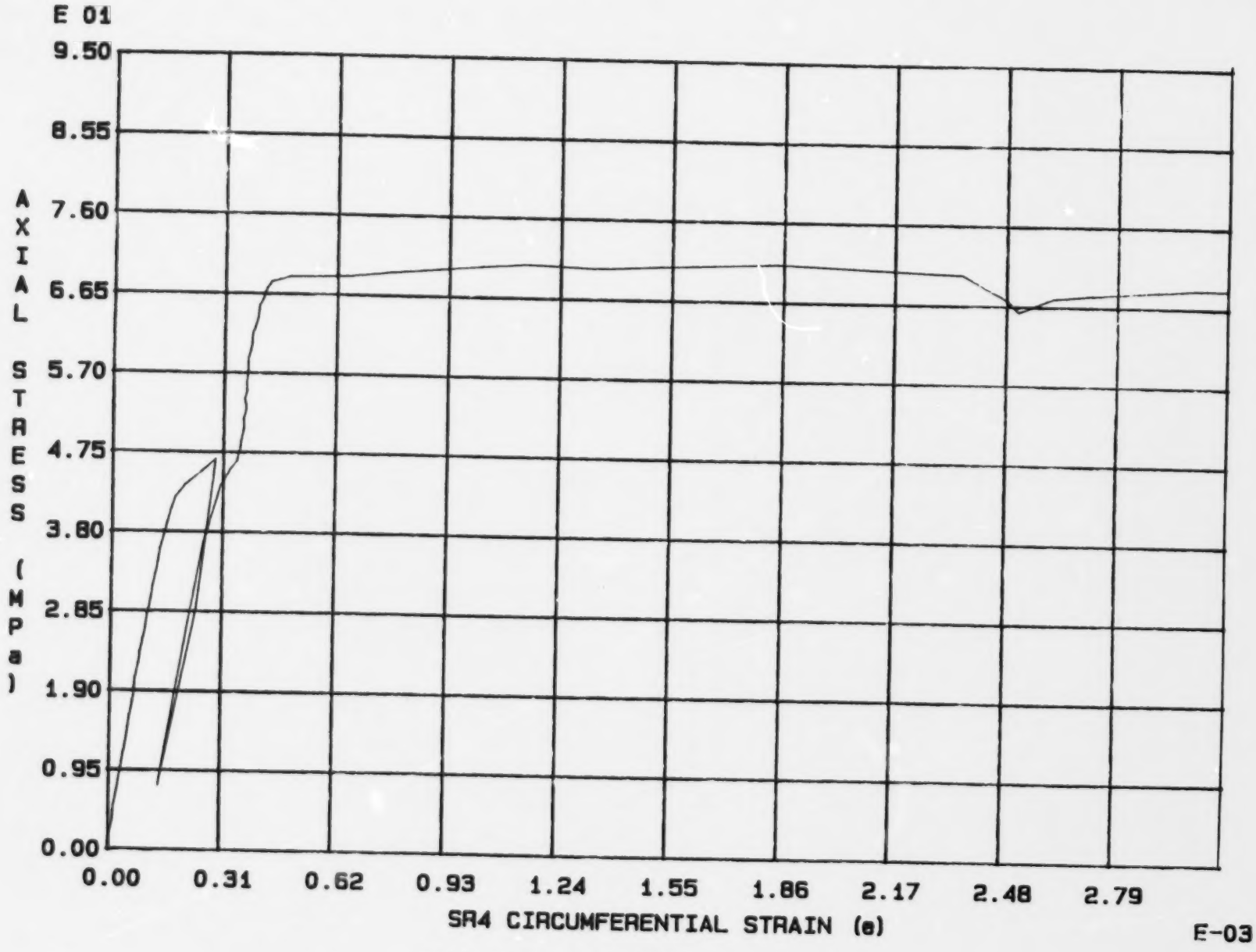

E 01
9.50
8.55
7.60
6.65
5.70
4.75
3.80
2.85
1.90
0.95
0.00
AXIAL STRESS (MPa)
0.00
0.31
0.62
0.93
1.24
1.55
1.86
2.17
2.48
2.79
SR4 CIRCUMFERENTIAL STRAIN (e)
E-03

Fig. D-6 E11U

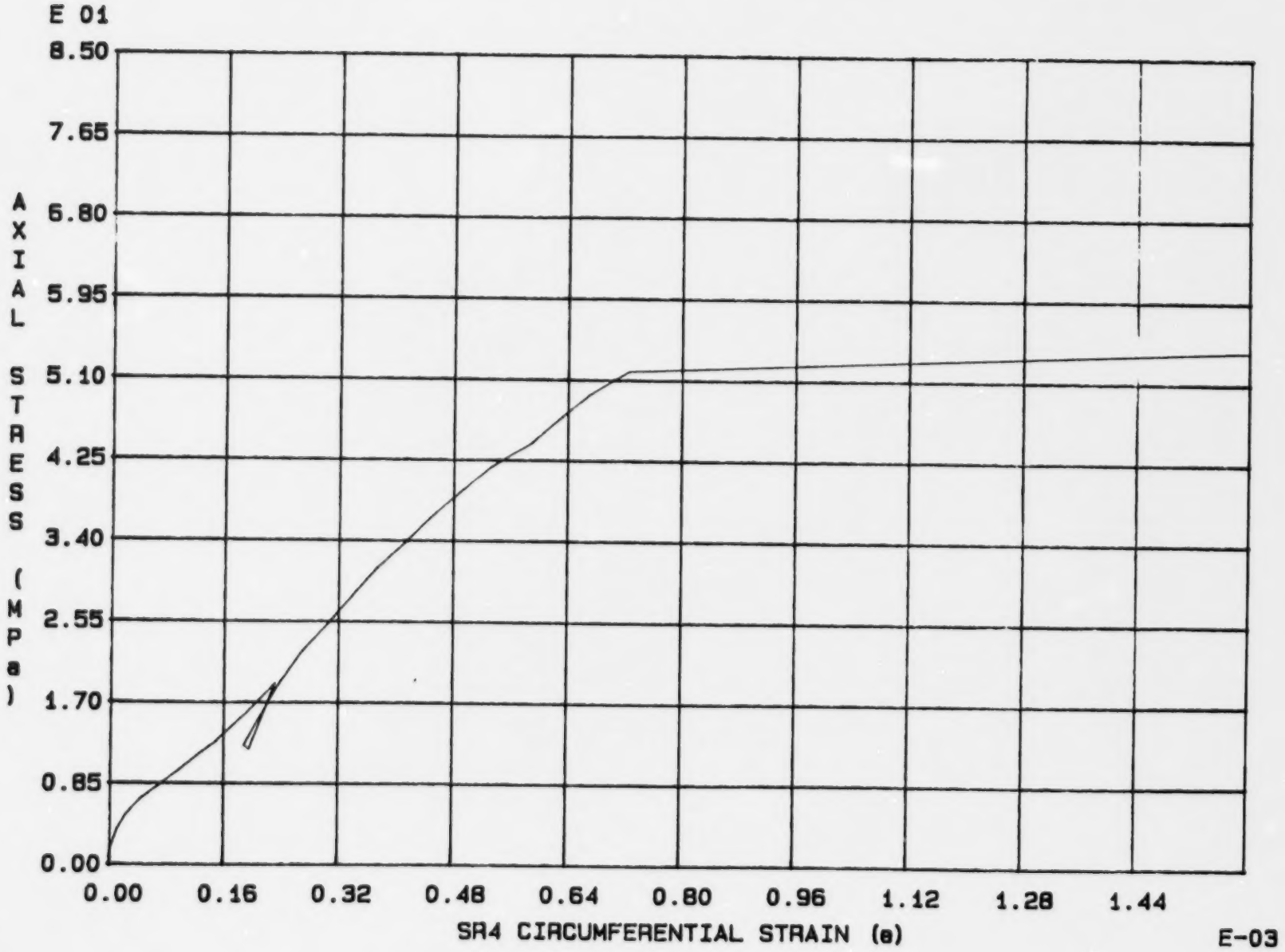

E 01
8.50
7.65
6.80
5.95
5.10
4.25
3.40
2.55
1.70
0.85
0.00
AXIAL STRESS (MPa)
0.00
0.16
0.32
0.48
0.64
0.80
0.96
1.12
1.28
1.44
SR4 CIRCUMFERENTIAL STRAIN (e)
E-03

Fig. D-7 E13U

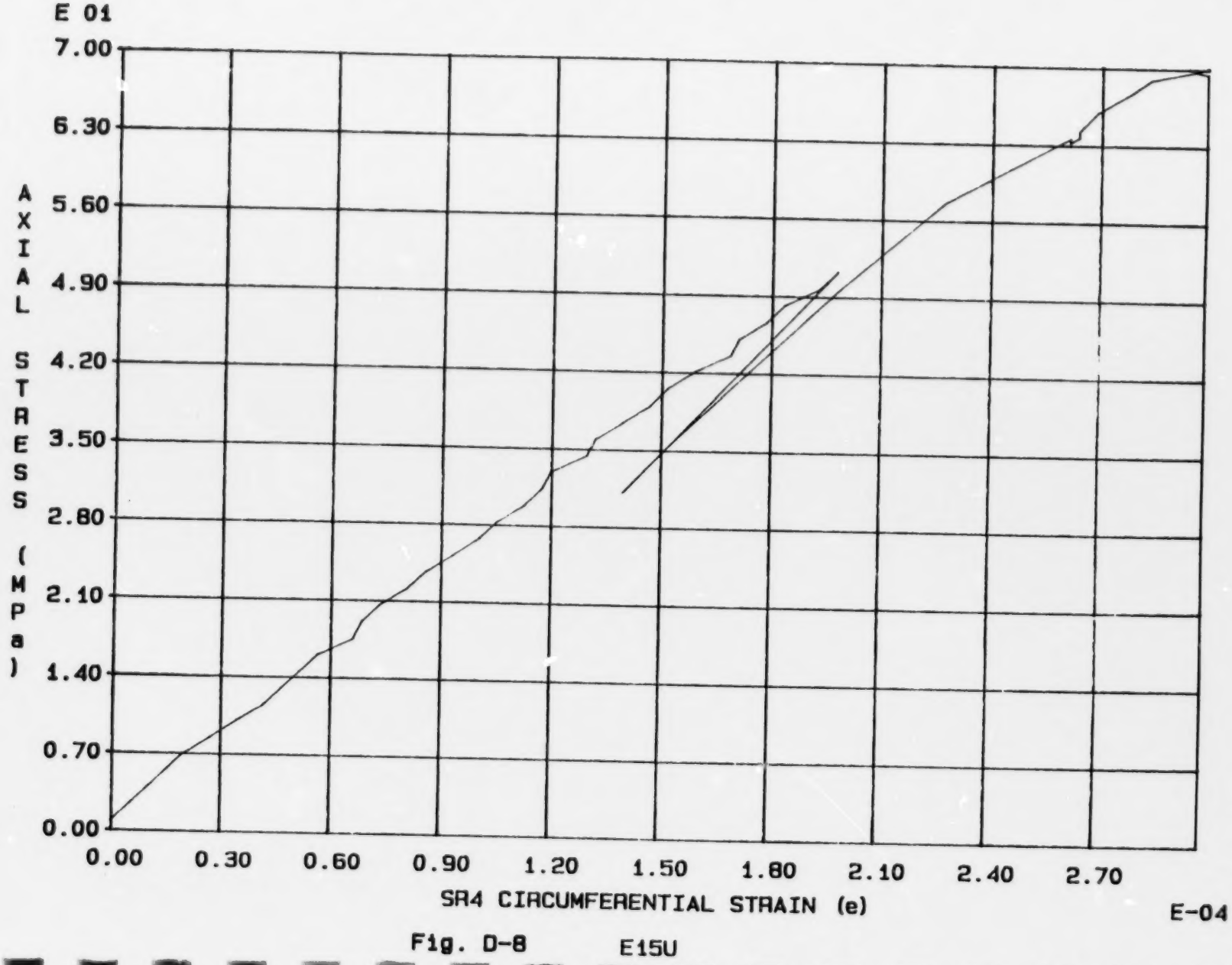

E 01
7.00
6.30
5.60
4.90
4.20
3.50
2.80
2.10
1.40
0.70
0.00
AXIAL STRESS (MPa)
0.00
0.30
0.60
0.90
1.20
1.50
1.80
2.10
2.40
2.70
SR4 CIRCUMFERENTIAL STRAIN (e)
E-04

Fig. D-8 E15U

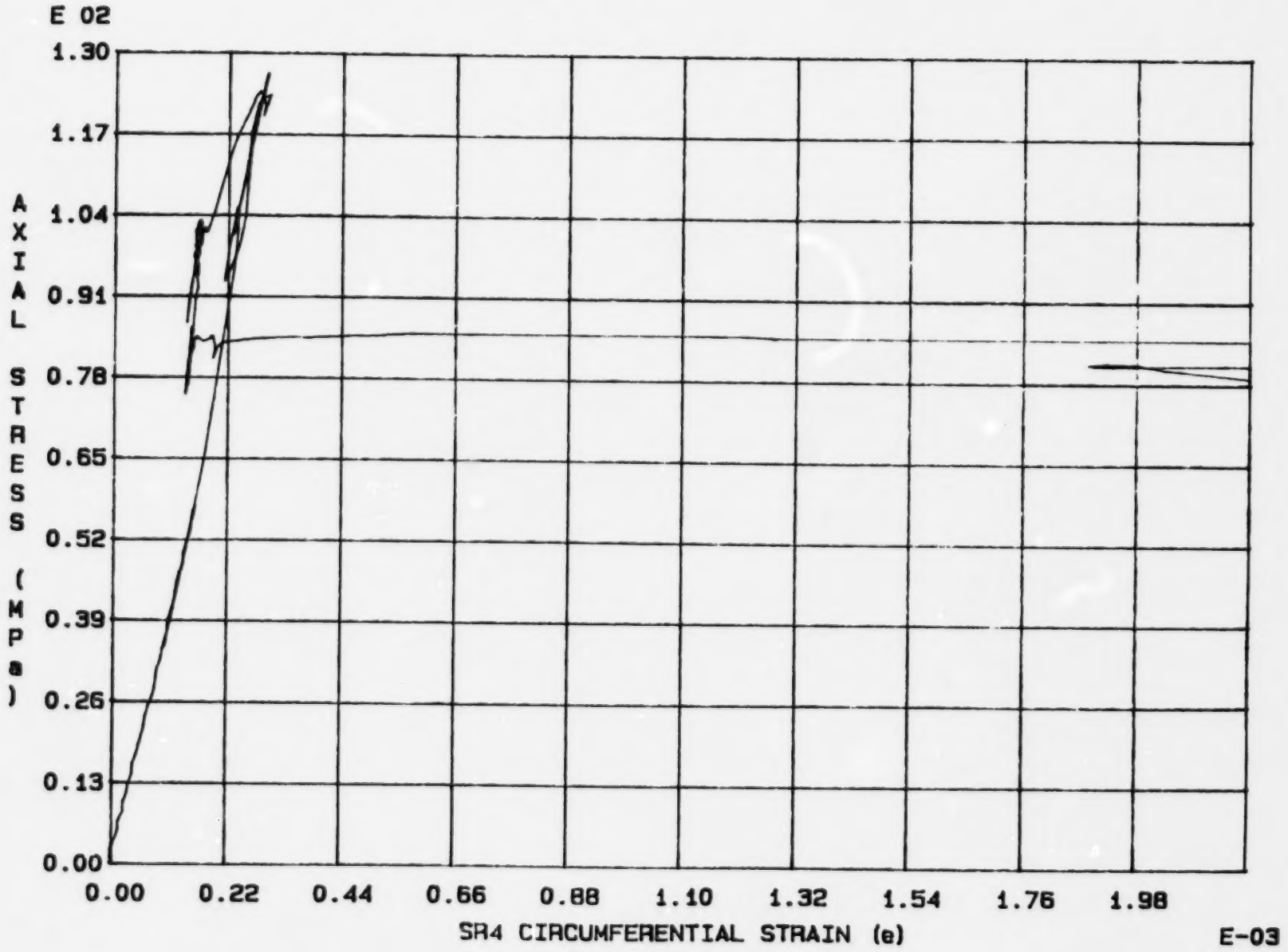

E 02
1.30
1.17
1.04
0.91
0.78
0.65
0.52
0.39
0.26
0.13
0.00
AXIAL STRESS (MPa)
0.00
0.22
0.44
0.66
0.88
1.10
1.32
1.54
1.76
1.98
SR4 CIRCUMFERENTIAL STRAIN (e)
E-03

Fig. D-9 E17U

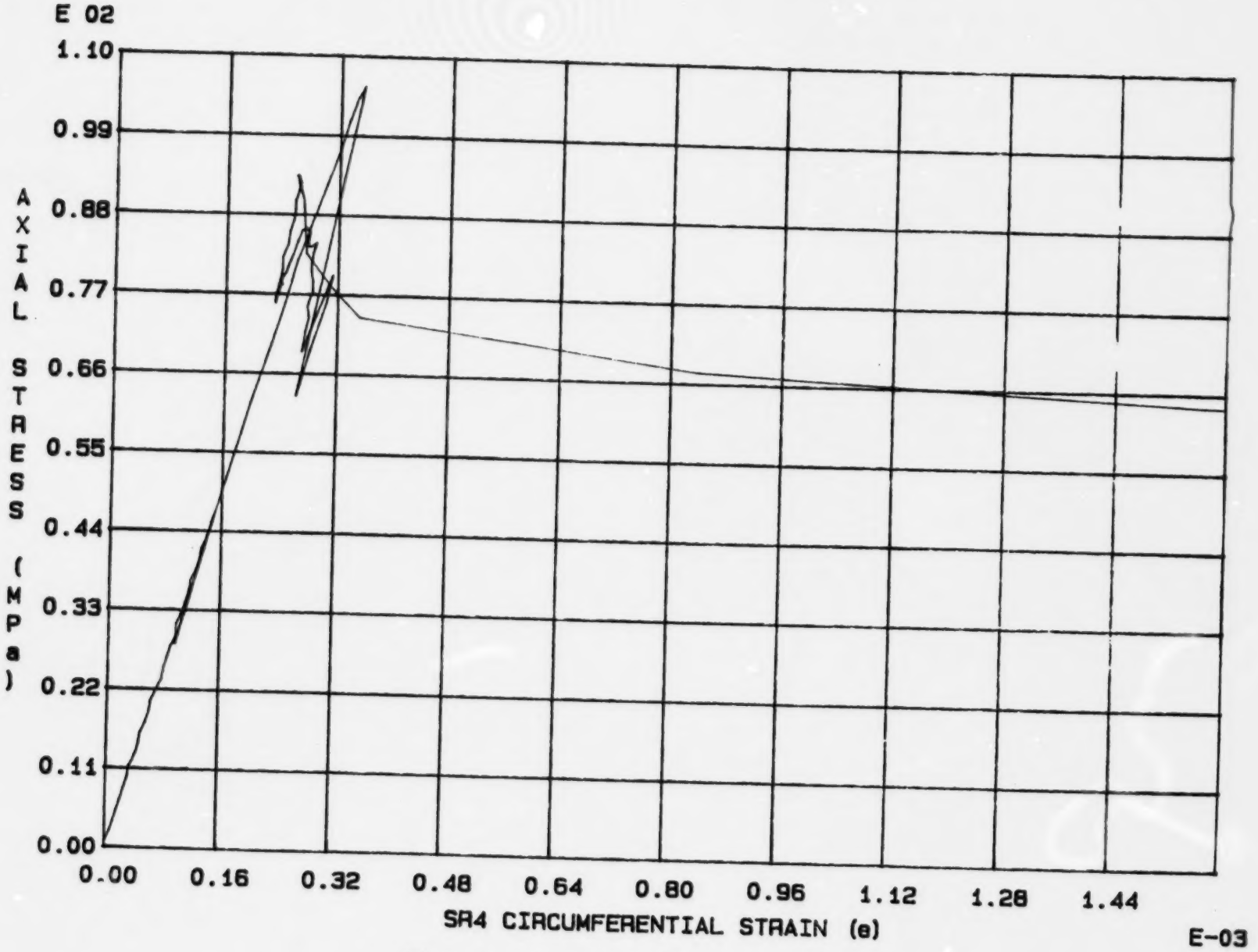

E 02
1.10
0.99
0.88
0.77
0.66
0.55
0.44
0.33
0.22
0.11
0.00
AXIAL STRESS (MPa)
0.00
0.16
0.32
0.48
0.64
0.80
0.96
1.12
1.28
1.44
SR4 CIRCUMFERENTIAL STRAIN (e)
E-03

Fig. D-10 E19U

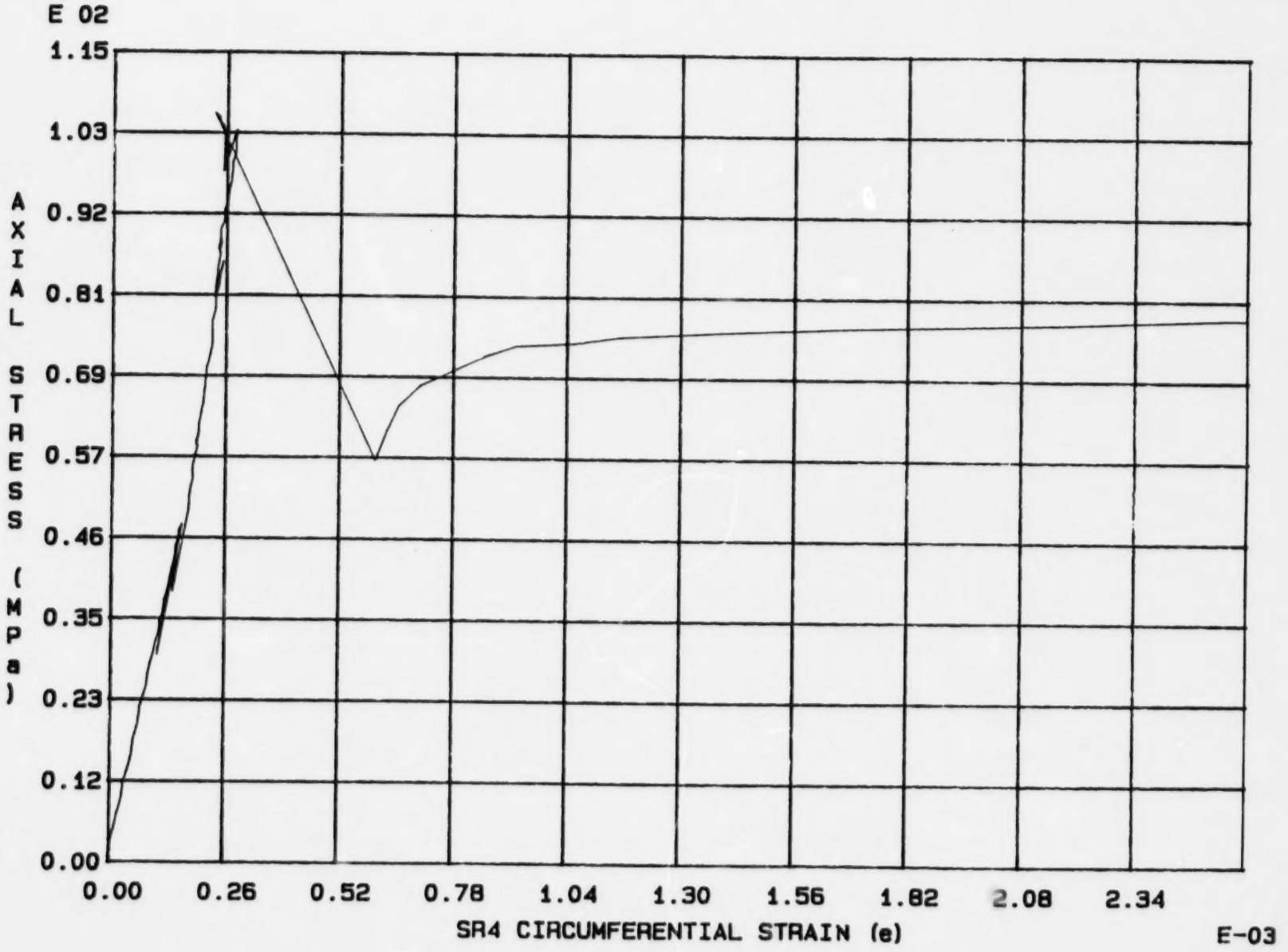

E 02
1.15
1.03
0.92
0.81
0.69
0.57
0.46
0.35
0.23
0.12
0.00
AXIAL STRESS (MPa)
0.00
0.26
0.52
0.78
1.04
1.30
1.56
1.82
2.08
2.34
SR4 CIRCUMFERENTIAL STRAIN (e)
E-03

Fig. D-11 E21U

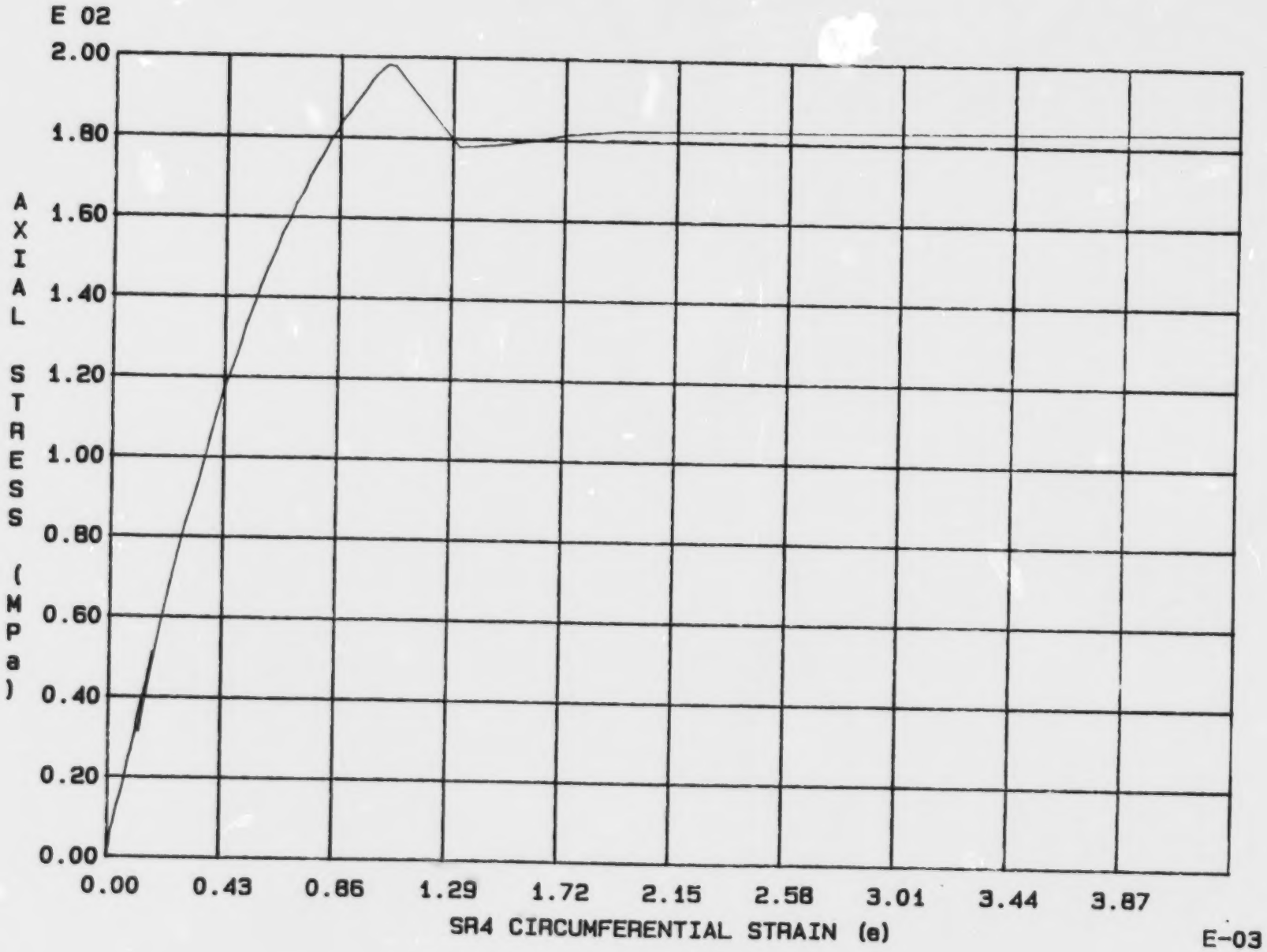

E 02
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
AXIAL STRESS (MPa)
0.00
0.43
0.86
1.29
1.72
2.15
2.58
3.01
3.44
3.87
SR4 CIRCUMFERENTIAL STRAIN (e)
E-03

Fig. D-12 E23U

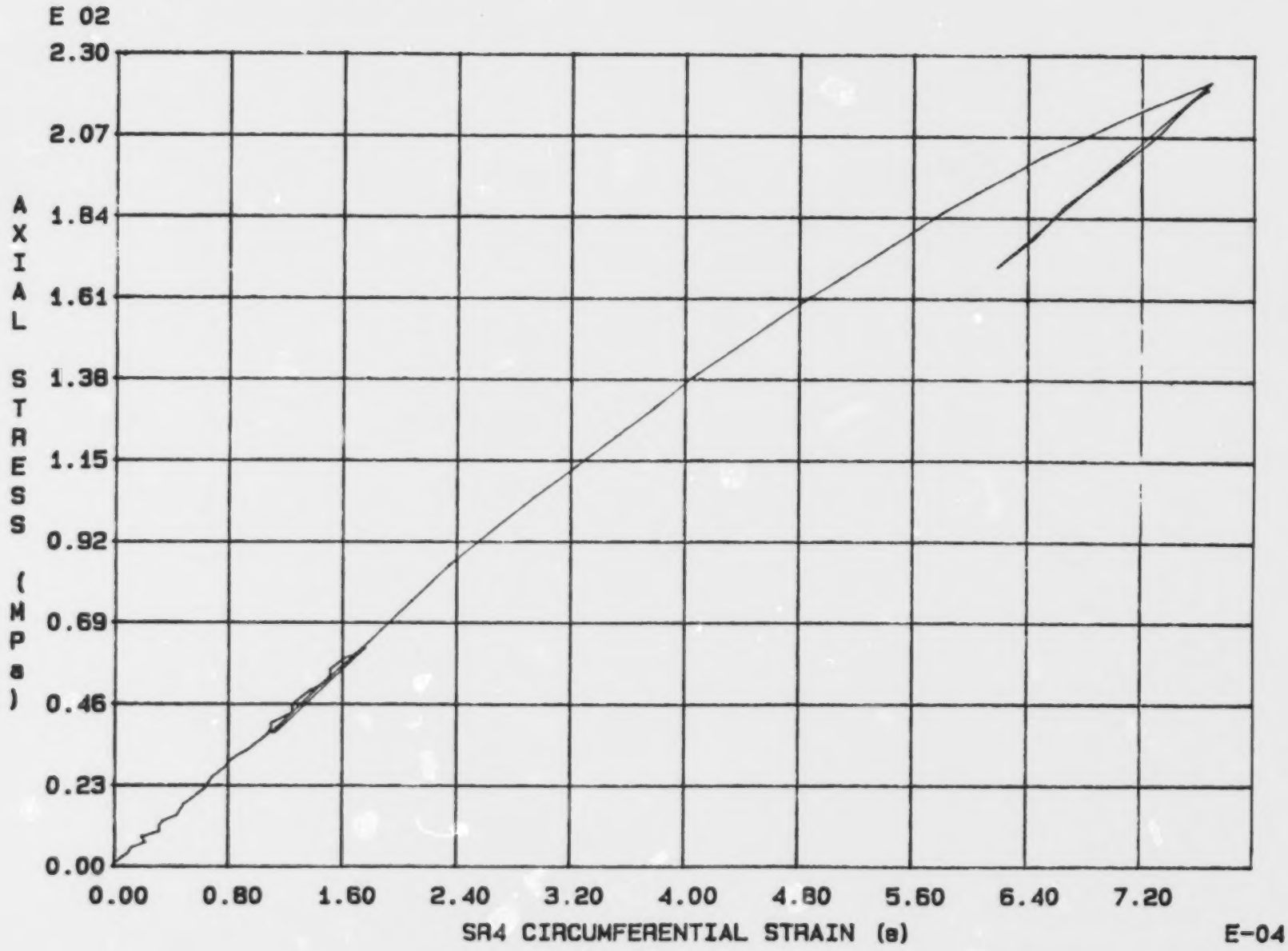

E 02
2.30
2.07
1.84
1.61
1.38
1.15
0.92
0.69
0.46
0.23
0.00
AXIAL STRESS (MPa)
0.00
0.80
1.60
2.40
3.20
4.00
4.80
5.60
6.40
7.20
SR4 CIRCUMFERENTIAL STRAIN (e)
E-04

Fig. D-13 E25U

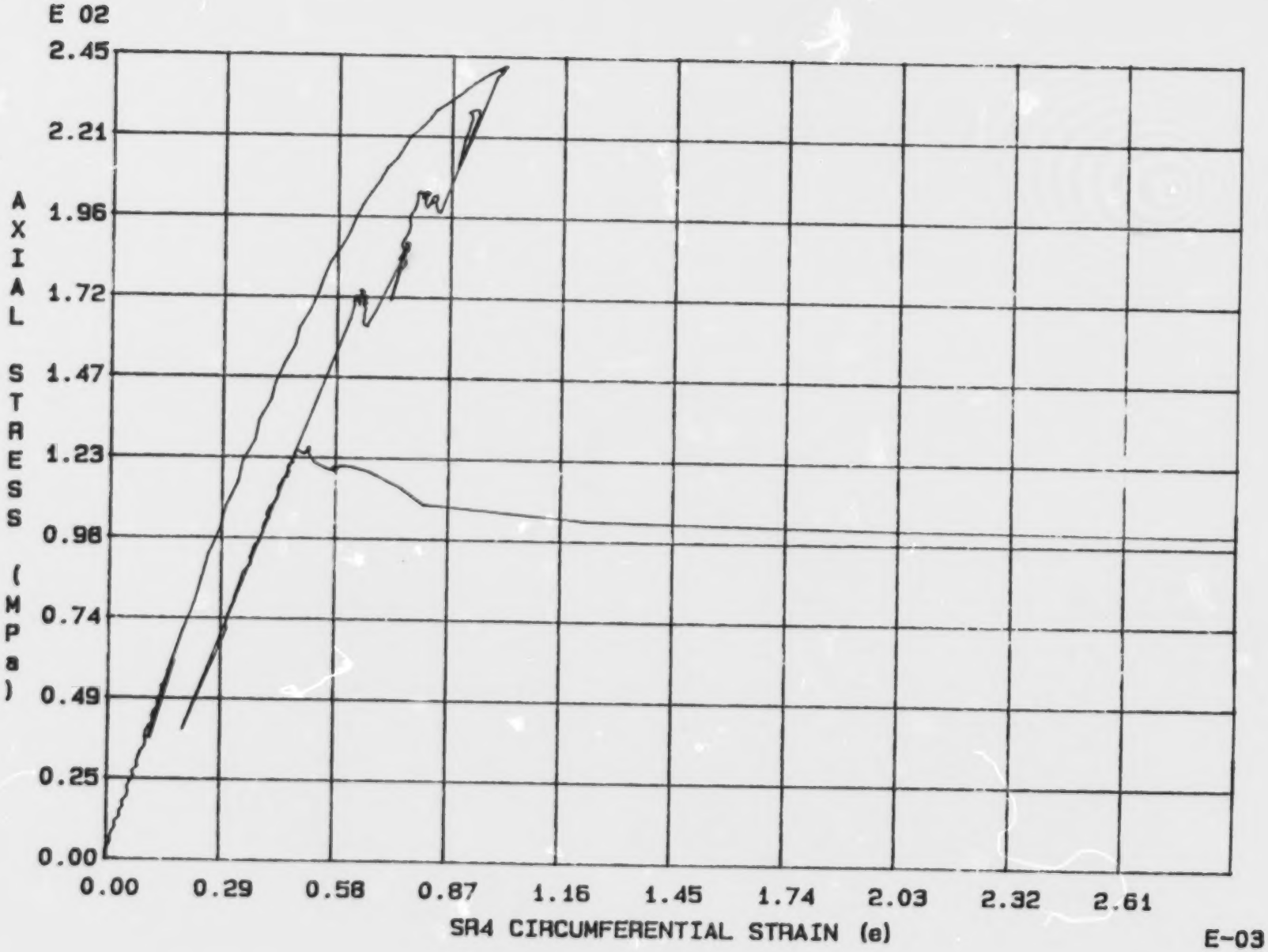

E 02
2.45
2.21
1.96
1.72
1.47
1.23
0.98
0.74
0.49
0.25
0.00
AXIAL STRESS (MPa)
0.00
0.29
0.58
0.87
1.16
1.45
1.74
2.03
2.32
2.61
SR4 CIRCUMFERENTIAL STRAIN (e)
E-03

Fig. D-14 E27U

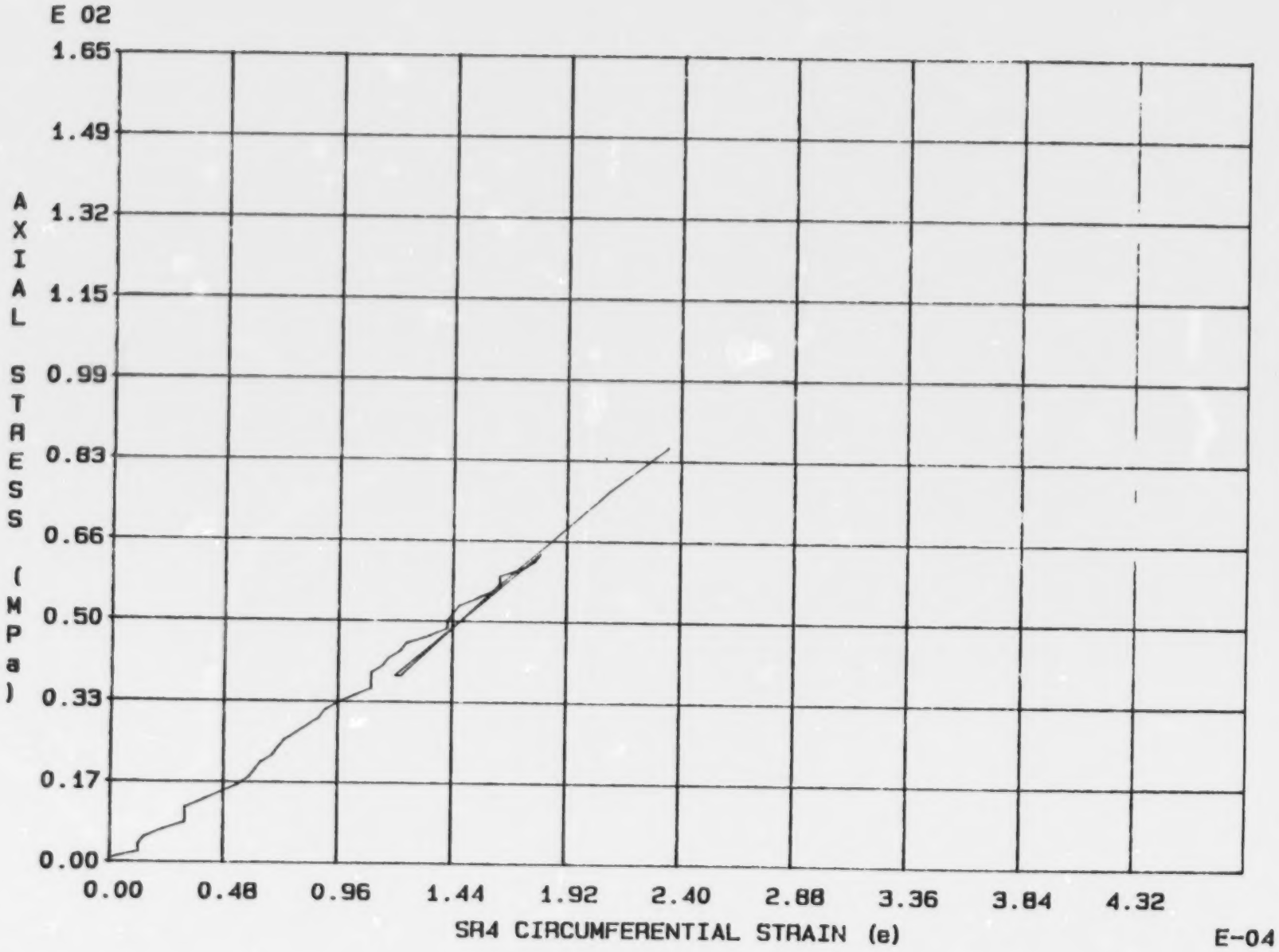

E 02
1.65
1.49
1.32
1.15
0.99
0.83
0.66
0.50
0.33
0.17
0.00
AXIAL STRESS (MPa)
0.00
0.48
0.96
1.44
1.92
2.40
2.88
3.36
3.84
4.32
SR4 CIRCUMFERENTIAL STRAIN (e)
E-04

Fig. D-15 - E29U

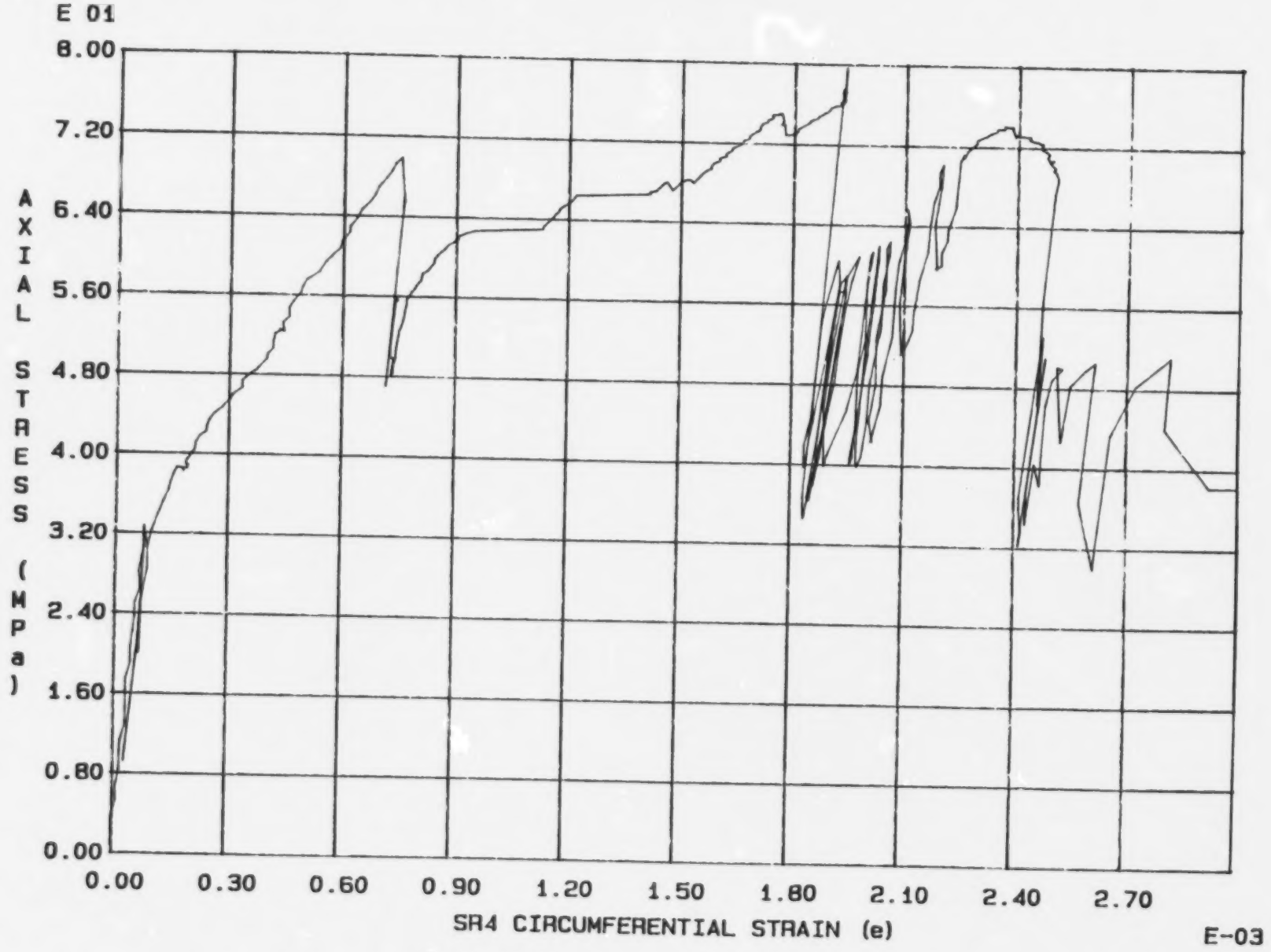

E 01
8.00
7.20
6.40
5.60
4.80
4.00
3.20
2.40
1.60
0.80
0.00
AXIAL STRESS (MPa)
0.00
0.30
0.60
0.90
1.20
1.50
1.80
2.10
2.40
2.70
SR4 CIRCUMFERENTIAL STRAIN (e)
E-03

Fig. D-16 E31U

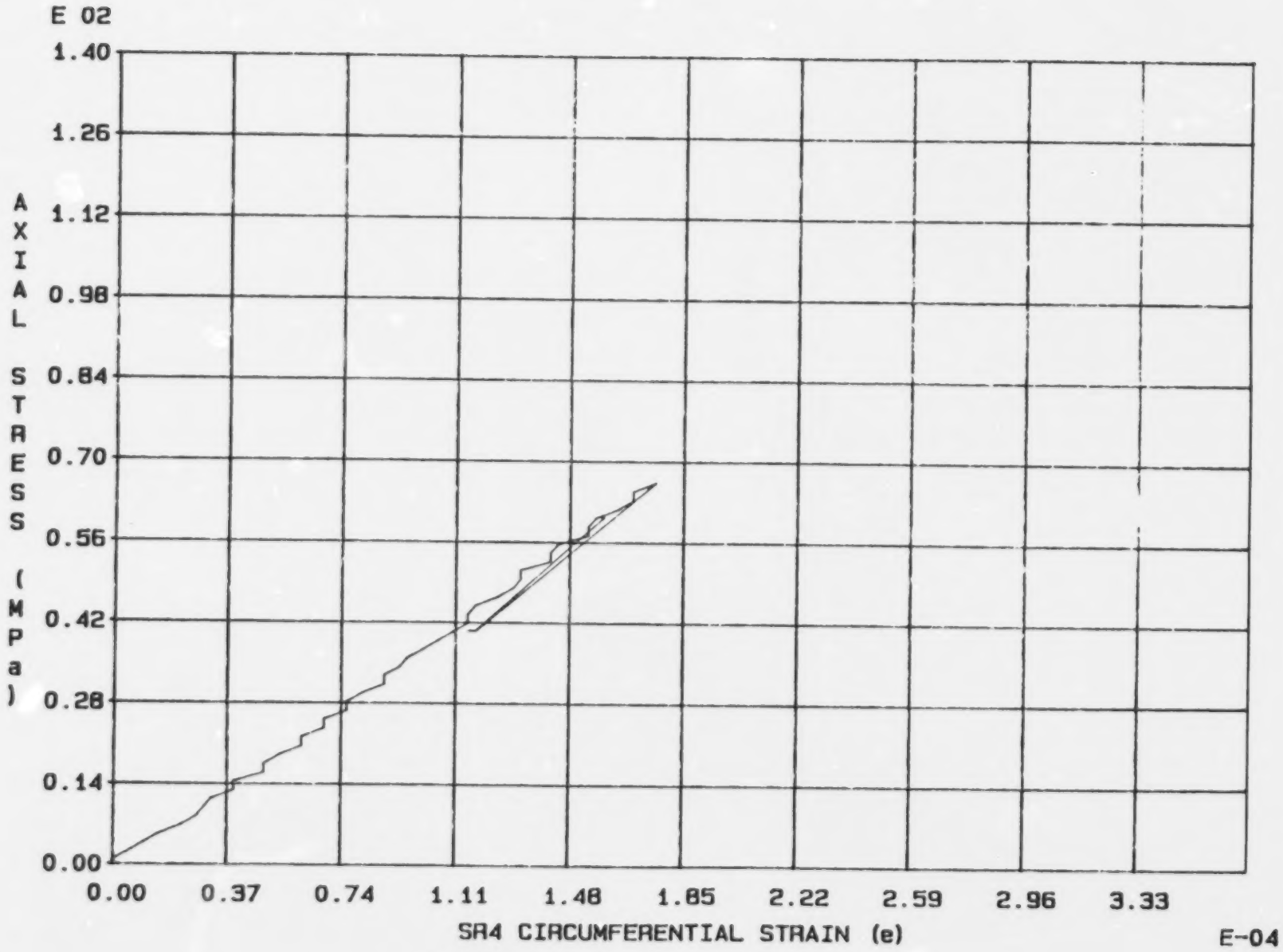

E 02
1.40
1.26
1.12
0.98
0.84
0.70
0.56
0.42
0.28
0.14
0.00
AXIAL STRESS (MPa)
0.00
0.37
0.74
1.11
1.48
1.85
2.22
2.59
2.96
3.33
SR4 CIRCUMFERENTIAL STRAIN (e)
E-04

Fig. D-17 E33U

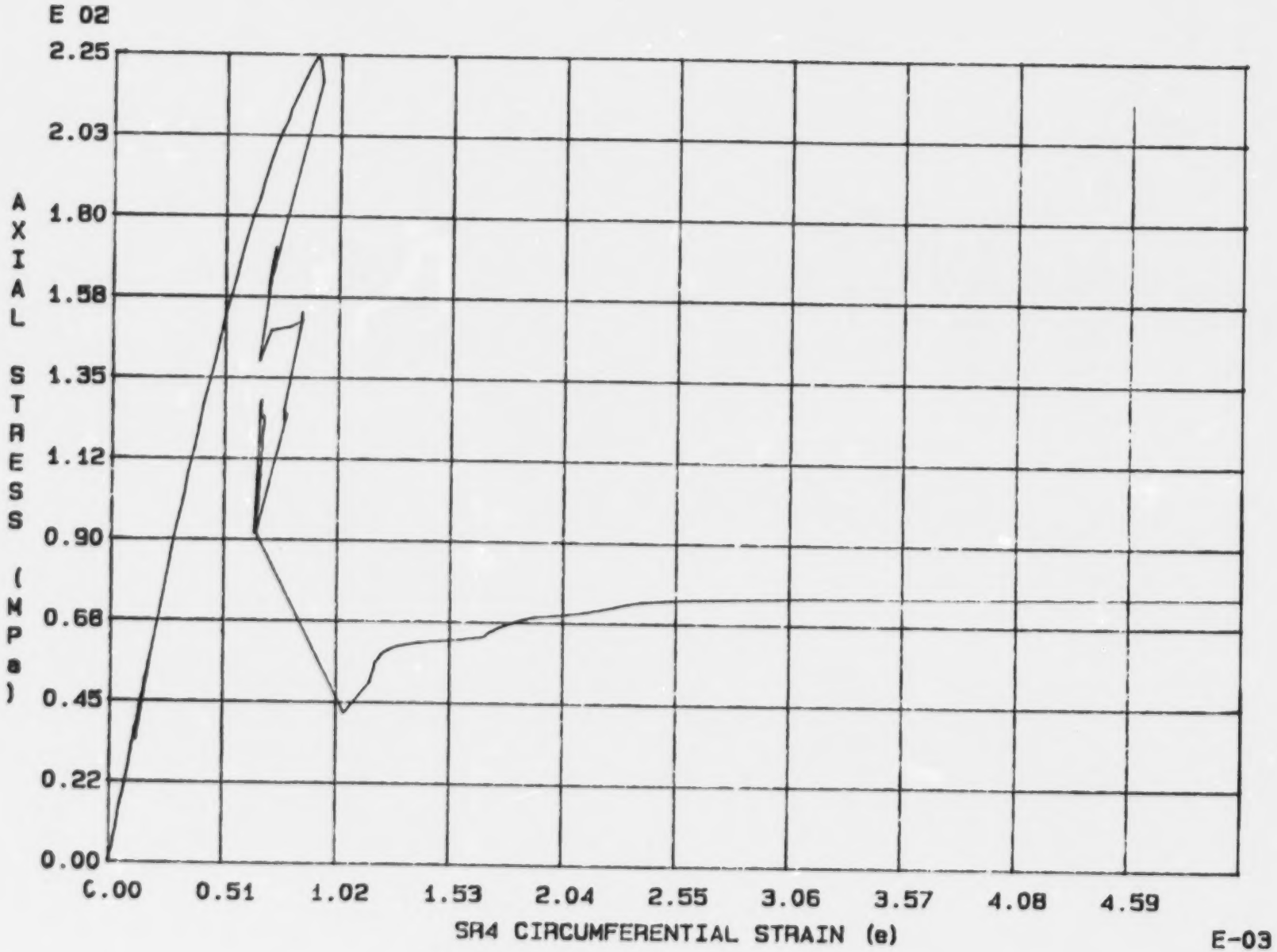

E 02
2.25
2.03
1.80
1.58
1.35
1.12
0.90
0.68
0.45
0.22
0.00
AXIAL STRESS (MPa)
0.00
0.51
1.02
1.53
2.04
2.55
3.06
3.57
4.08
4.59
SR4 CIRCUMFERENTIAL STRAIN (e)
E-03

Fig. D-18 E35U

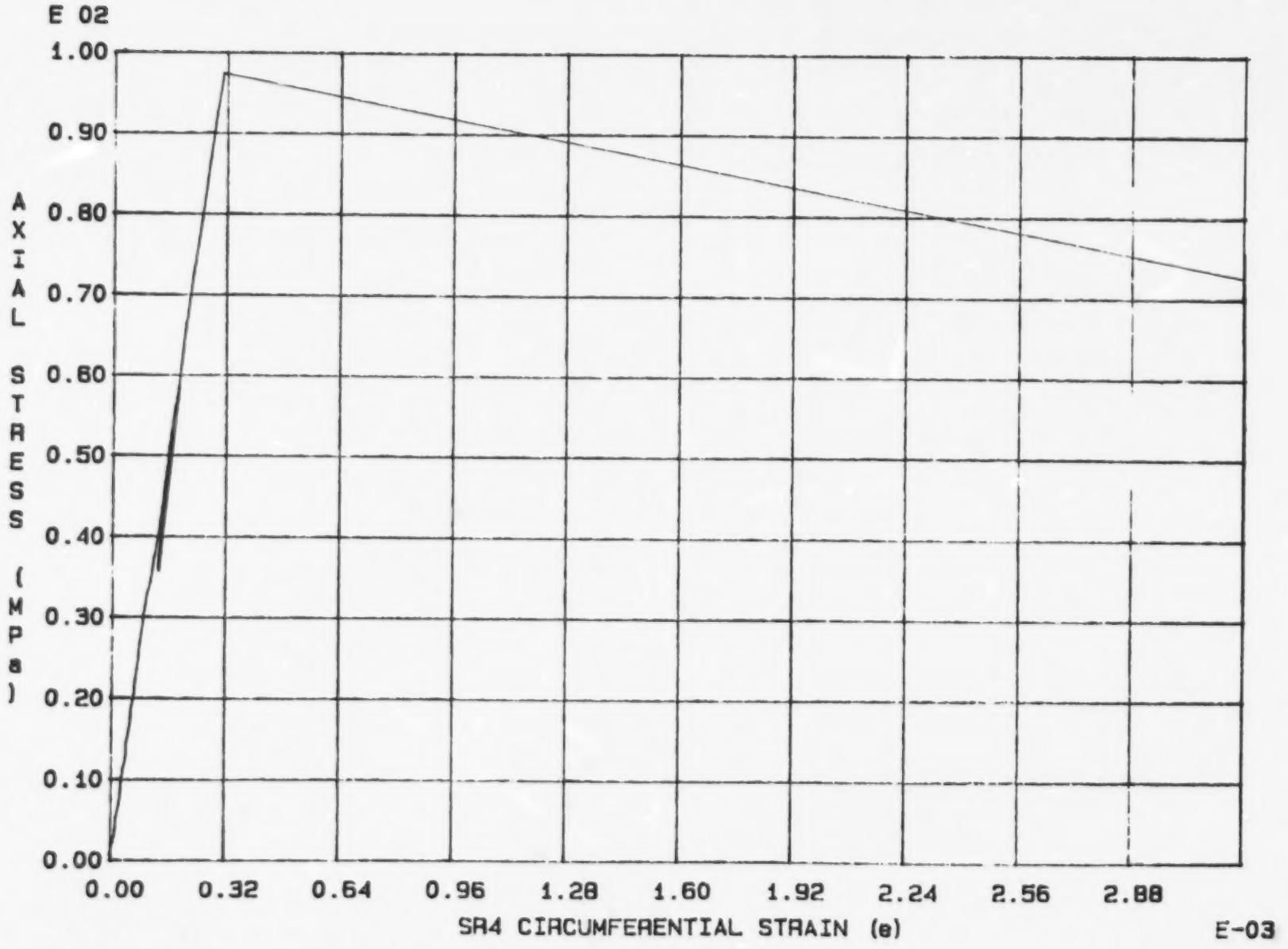

E 02
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
AXIAL STRESS (MPa)
0.00
0.32
0.64
0.96
1.28
1.60
1.92
2.24
2.56
2.88
SR4 CIRCUMFERENTIAL STRAIN (e)
E-03

Fig. D-19 E37U

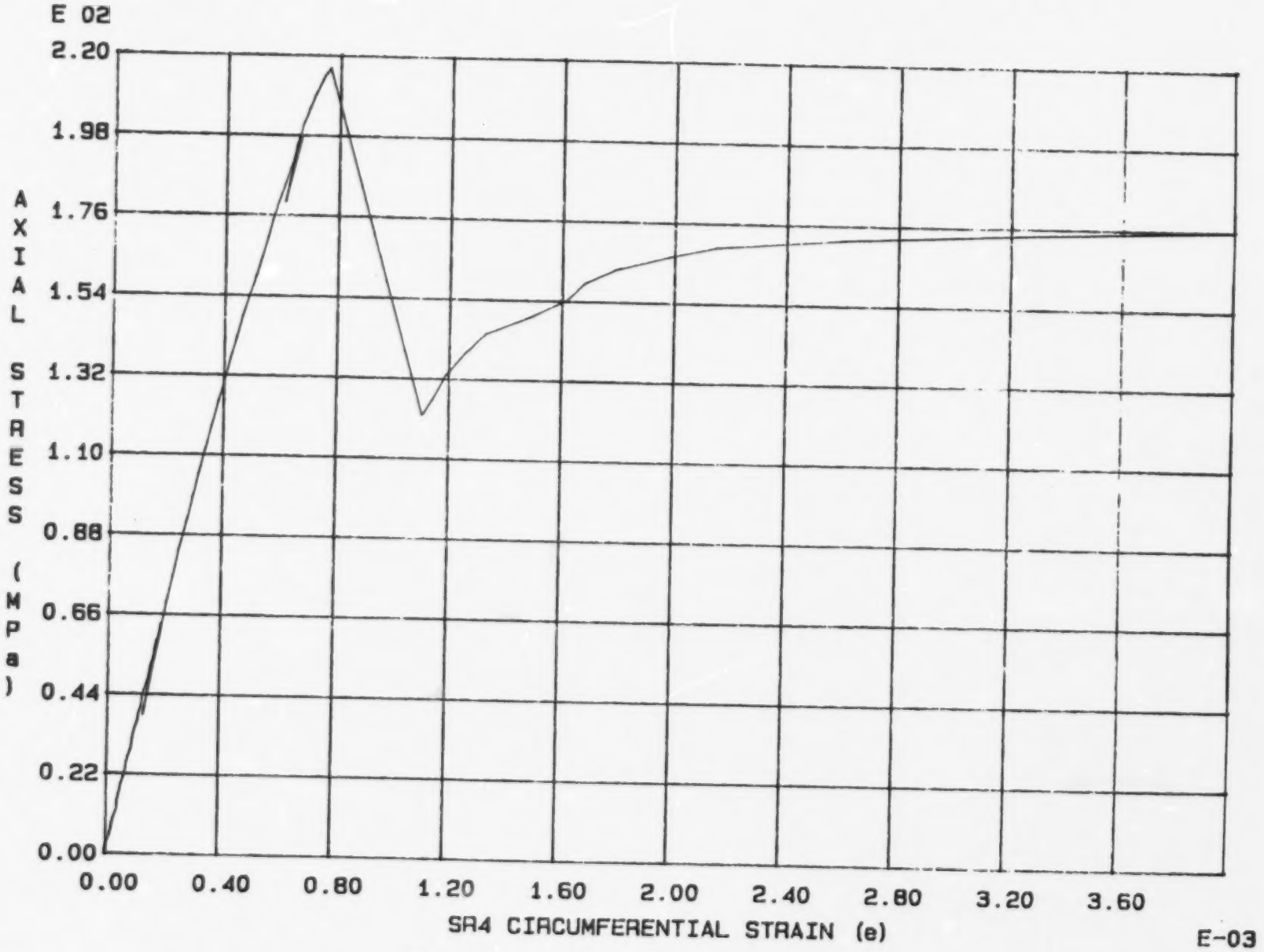

E 02
2.20
1.98
1.76
1.54
1.32
1.10
0.88
0.66
0.44
0.22
0.00
AXIAL STRESS (MPa)
0.00
0.40
0.80
1.20
1.60
2.00
2.40
2.80
3.20
3.60
SR4 CIRCUMFERENTIAL STRAIN (e)
E-03

Fig. D-20 E39U

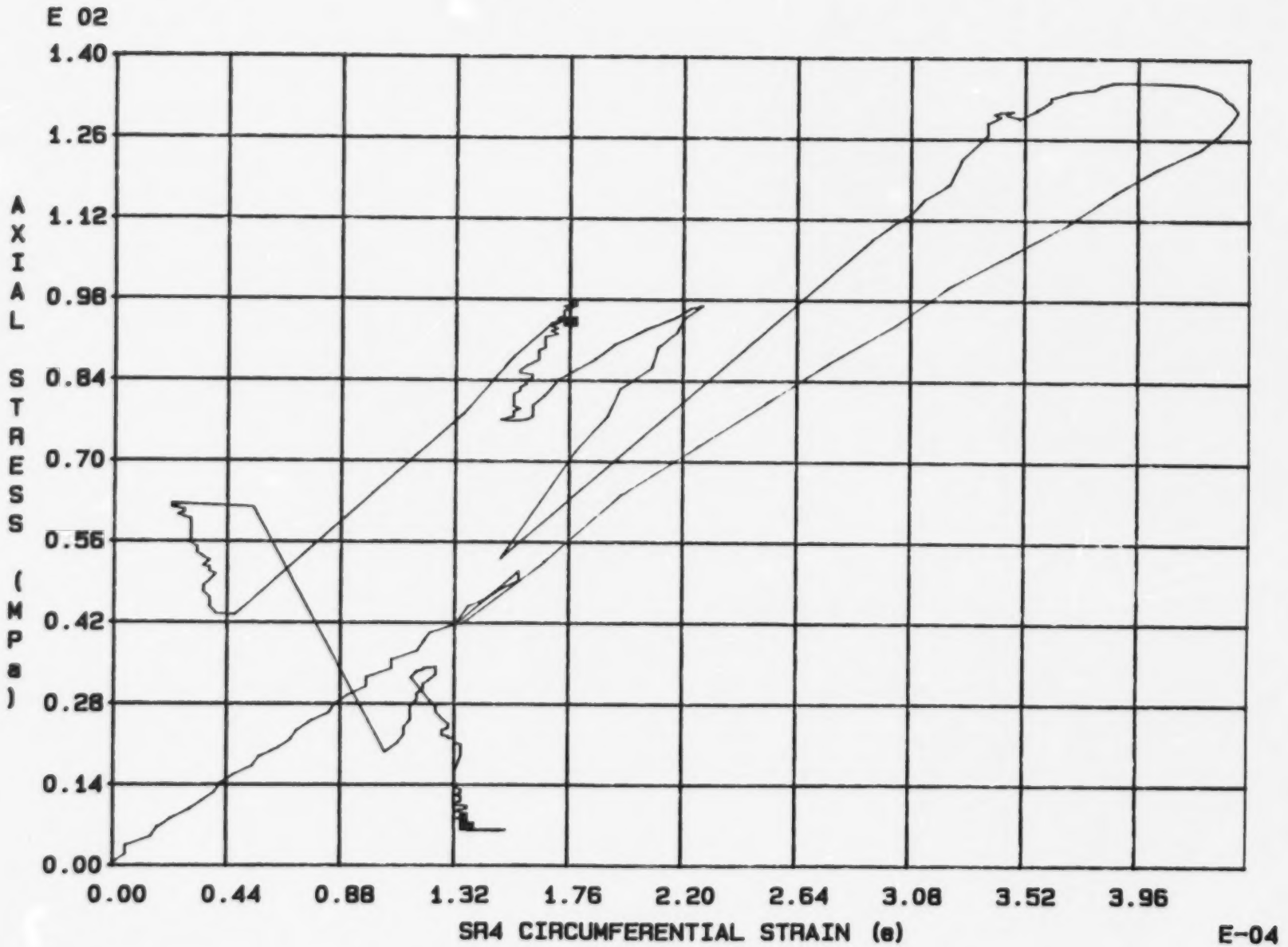

E 02
1.40
1.26
1.12
0.98
0.84
0.70
0.56
0.42
0.28
0.14
0.00
AXIAL STRESS (MPa)
0.00
0.44
0.88
1.32
1.76
2.20
2.64
3.08
3.52
3.96
SR4 CIRCUMFERENTIAL STRAIN (e)
E-04

Fig. D-21 E41U

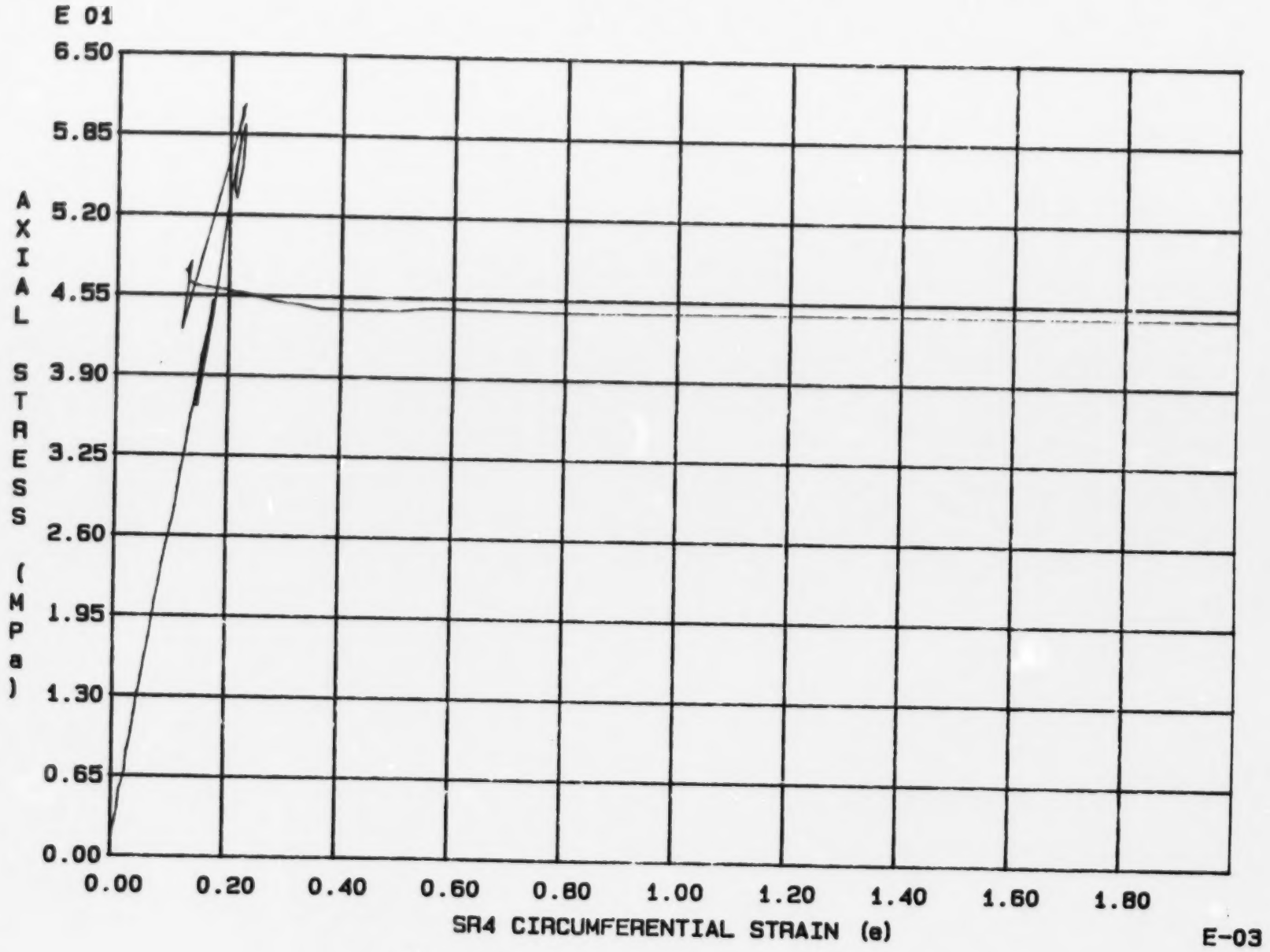

E 01
6.50
5.85
5.20
4.55
3.90
3.25
2.60
1.95
1.30
0.65
0.00
AXIAL STRESS (MPa)
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
1.60
1.80
SR4 CIRCUMFERENTIAL STRAIN (e)
E-03

Fig. D-22 E43U

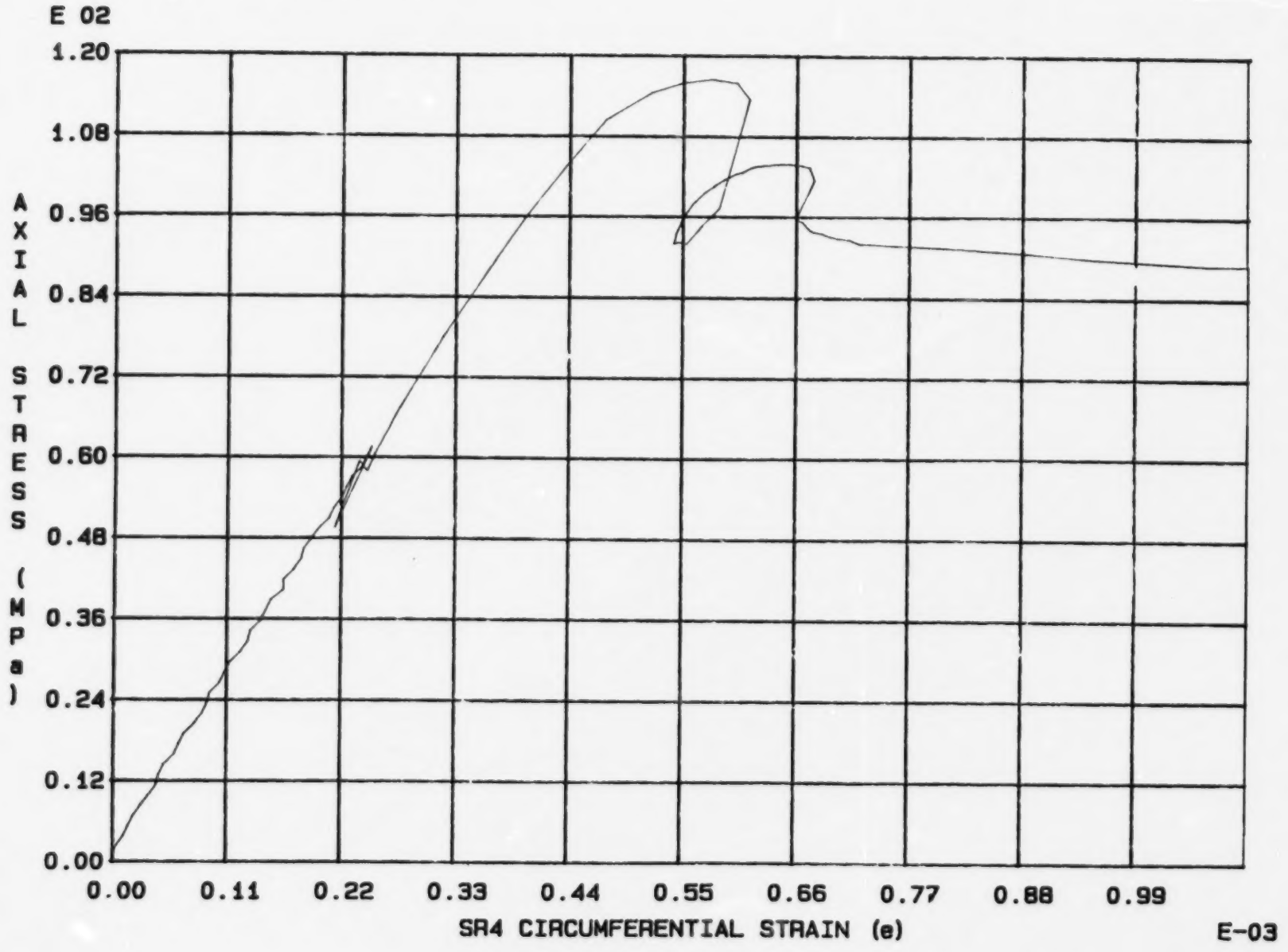

E 02
1.20
1.08
0.96
0.84
0.72
0.60
0.48
0.36
0.24
0.12
0.00
AXIAL STRESS (MPa)
0.00
0.11
0.22
0.33
0.44
0.55
0.66
0.77
0.88
0.99
SR4 CIRCUMFERENTIAL STRAIN (e)
E-03

Fig. D-23 E45U

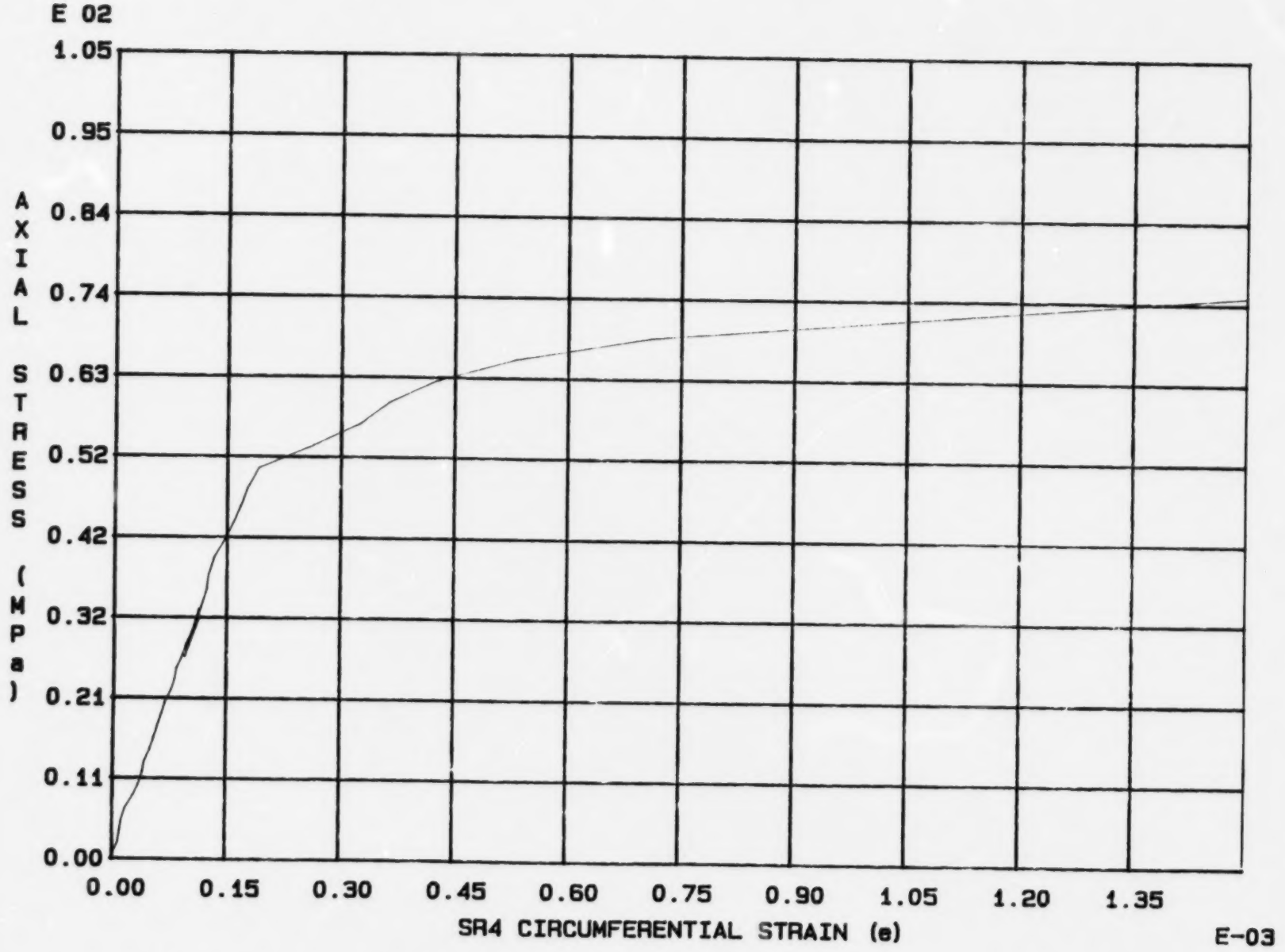
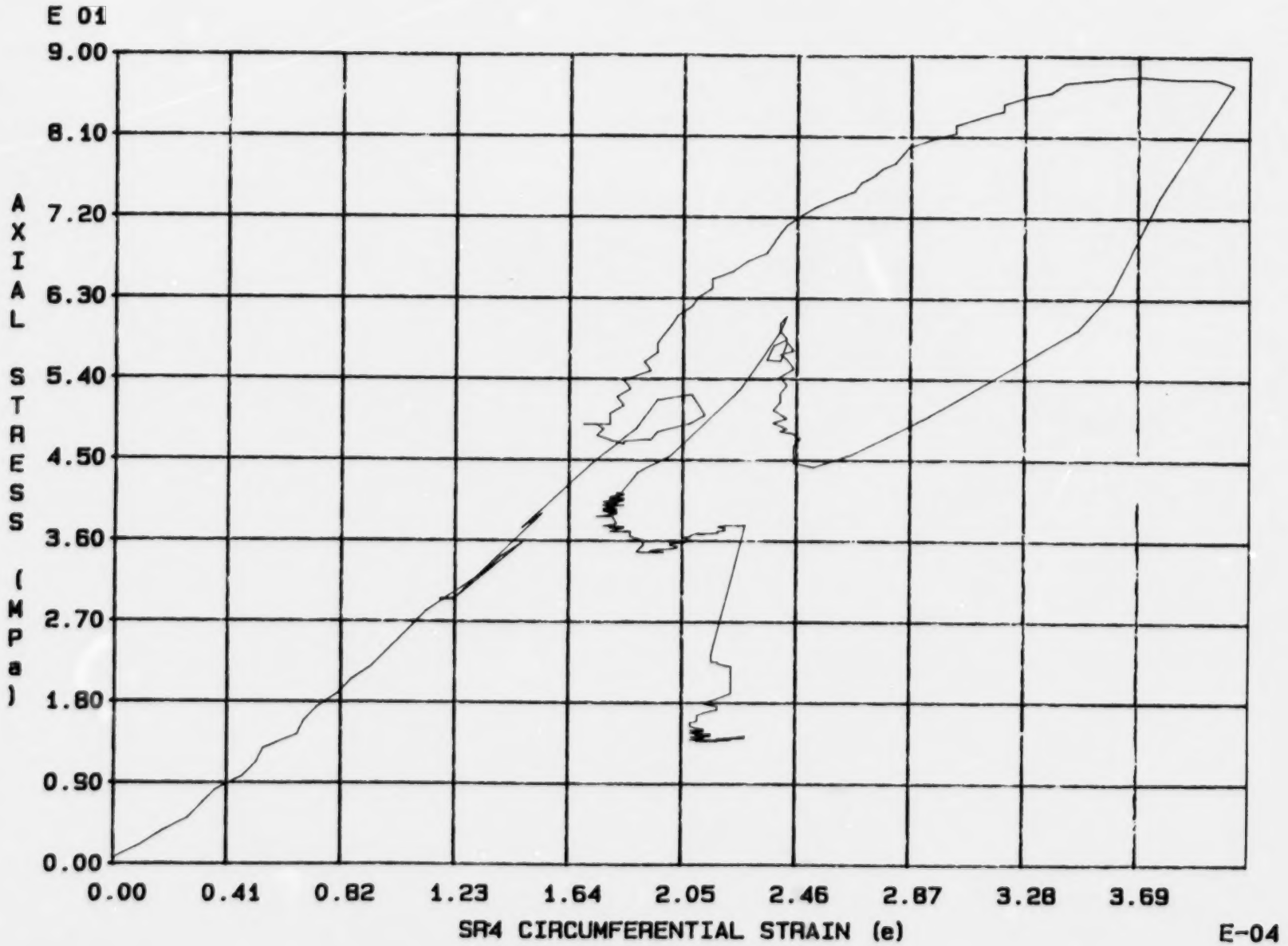

E 02
1.05
0.95
0.84
0.74
0.63
0.52
0.42
0.32
0.21
0.11
0.00
AXIAL STRESS (MPa)
0.00
0.15
0.30
0.45
0.60
0.75
0.90
1.05
1.20
1.35
SR4 CIRCUMFERENTIAL STRAIN (e)
E-03

Fig. D-24 E47U


E 01
9.00
8.10
7.20
6.30
5.40
4.50
3.60
2.70
1.80
0.90
0.00
AXIAL STRESS (MPa)
0.00
0.41
0.82
1.23
1.64
2.05
2.46
2.87
3.28
3.69
SR4 CIRCUMFERENTIAL STRAIN (e)
E-04

E49U

Fig. D-25

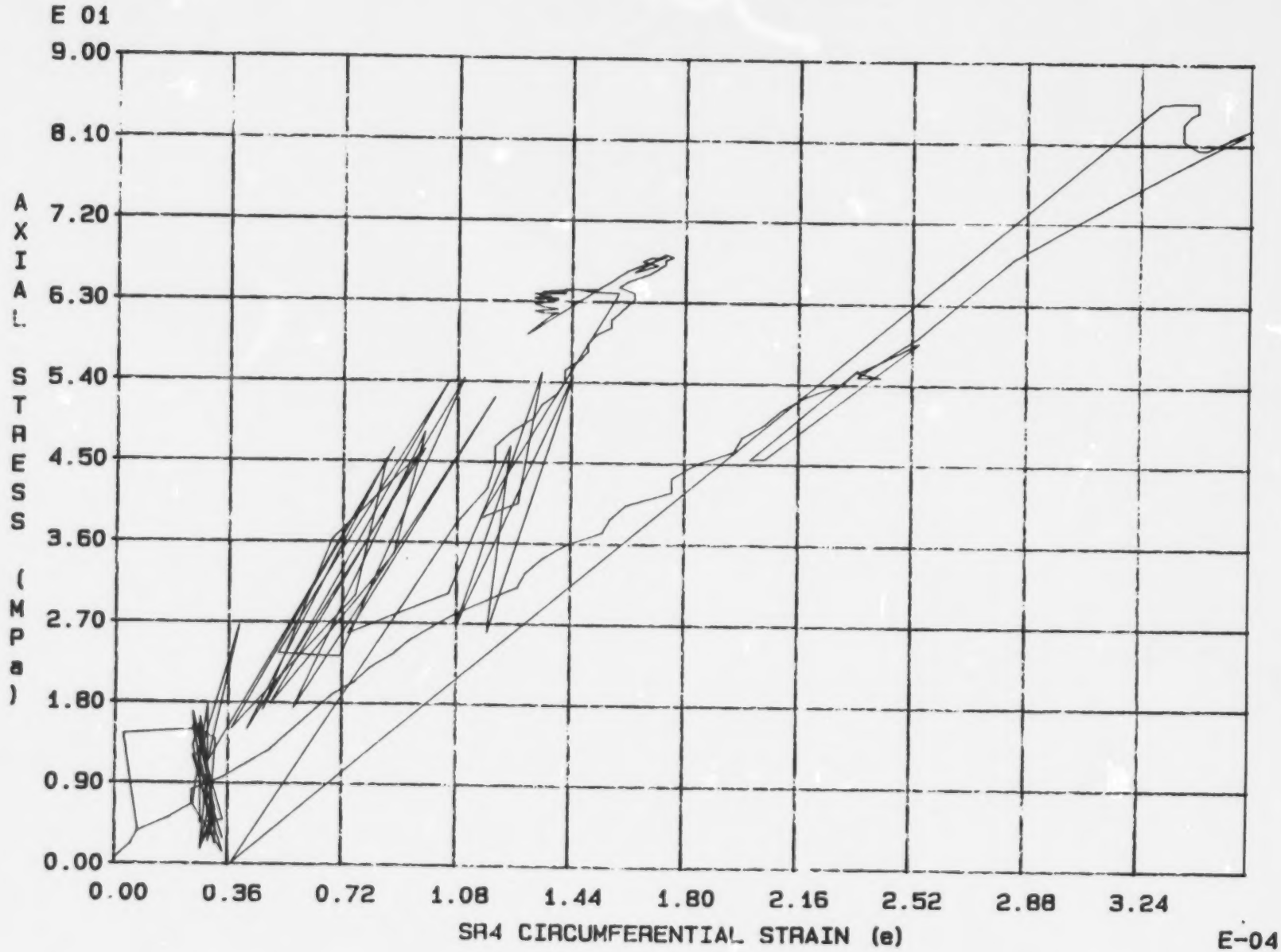

E 01
9.00
8.10
7.20
6.30
5.40
4.50
3.60
2.70
1.80
0.90
0.00
AXIAL STRESS (MPa)
0.00
0.36
0.72
1.08
1.44
1.80
2.16
2.52
2.88
3.24
SR4 CIRCUMFERENTIAL STRAIN (e)
E-04

Fig. D-26 E51U

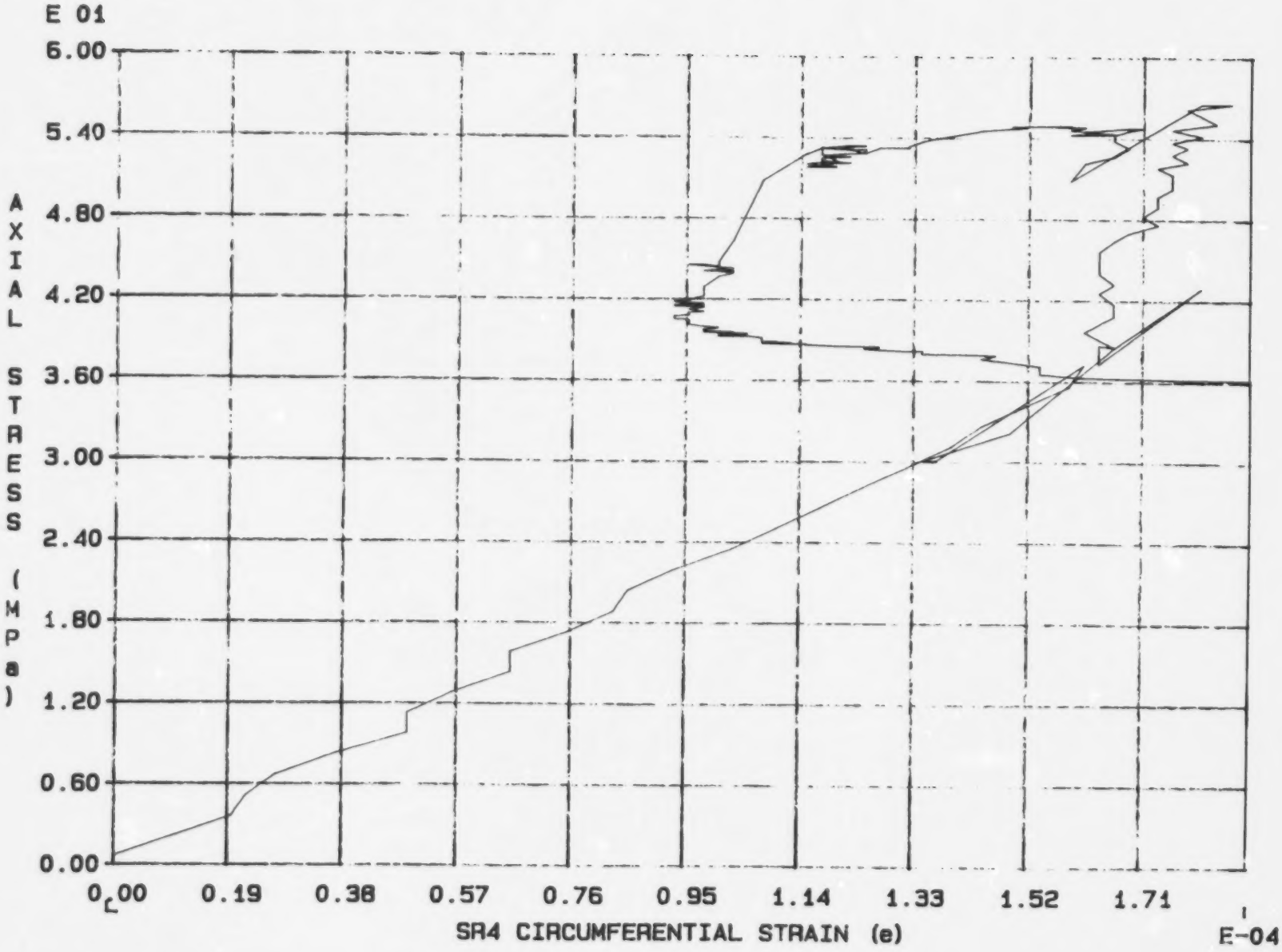

E 01
6.00
5.40
4.80
4.20
3.60
3.00
2.40
1.80
1.20
0.60
0.00
AXIAL STRESS (MPa)
0.00
0.19
0.38
0.57
0.76
0.95
1.14
1.33
1.52
1.71
SR4 CIRCUMFERENTIAL STRAIN (e)
E-04

Fig. D-27 E53U

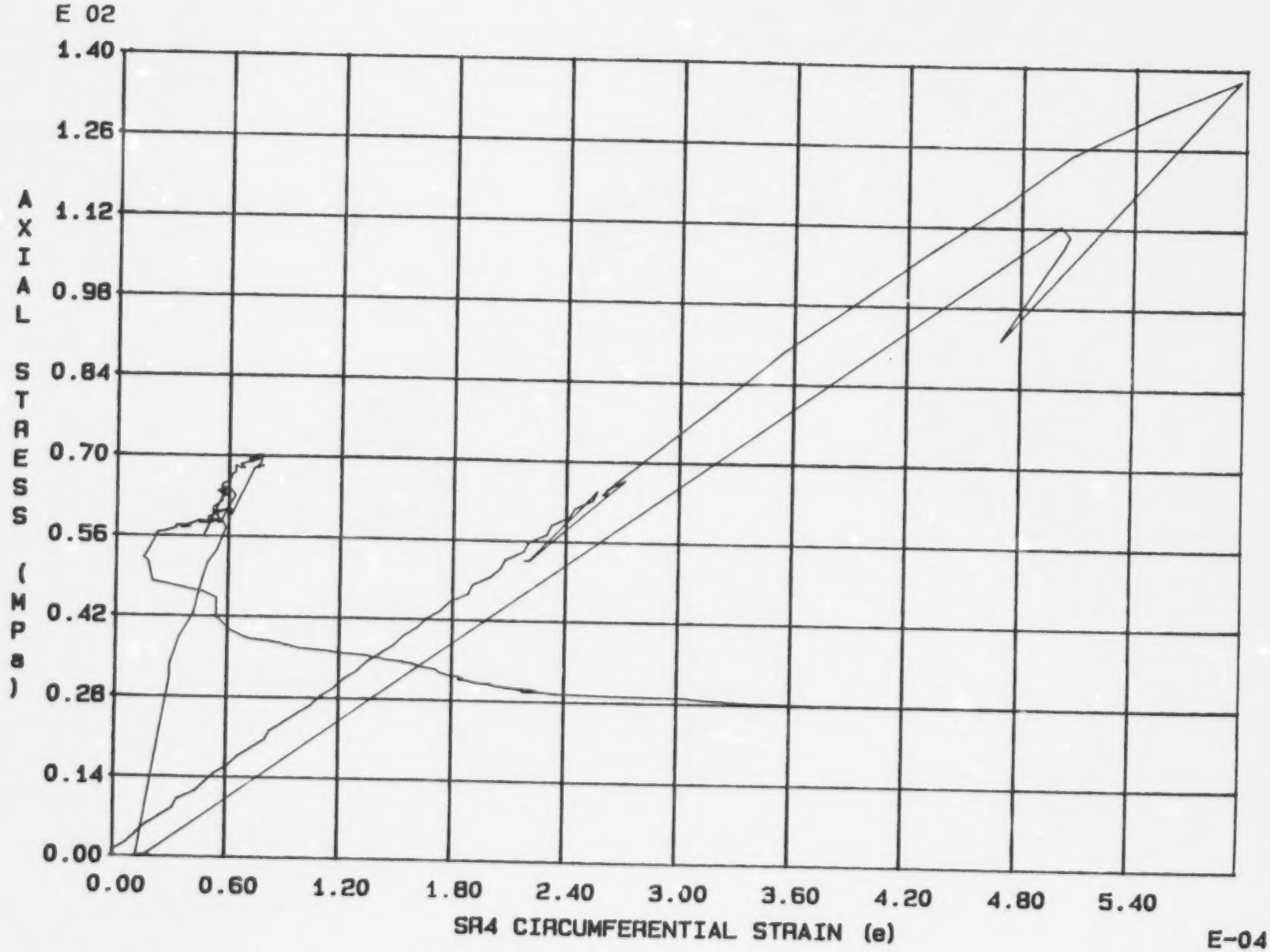

E 02
1.40
1.26
1.12
0.98
0.84
0.70
0.56
0.42
0.28
0.14
0.00
AXIAL STRESS (MPa)
0.00
0.60
1.20
1.80
2.40
3.00
3.60
4.20
4.80
5.40
SR4 CIRCUMFERENTIAL STRAIN (e)
E-04

Fig. D-28 E55U

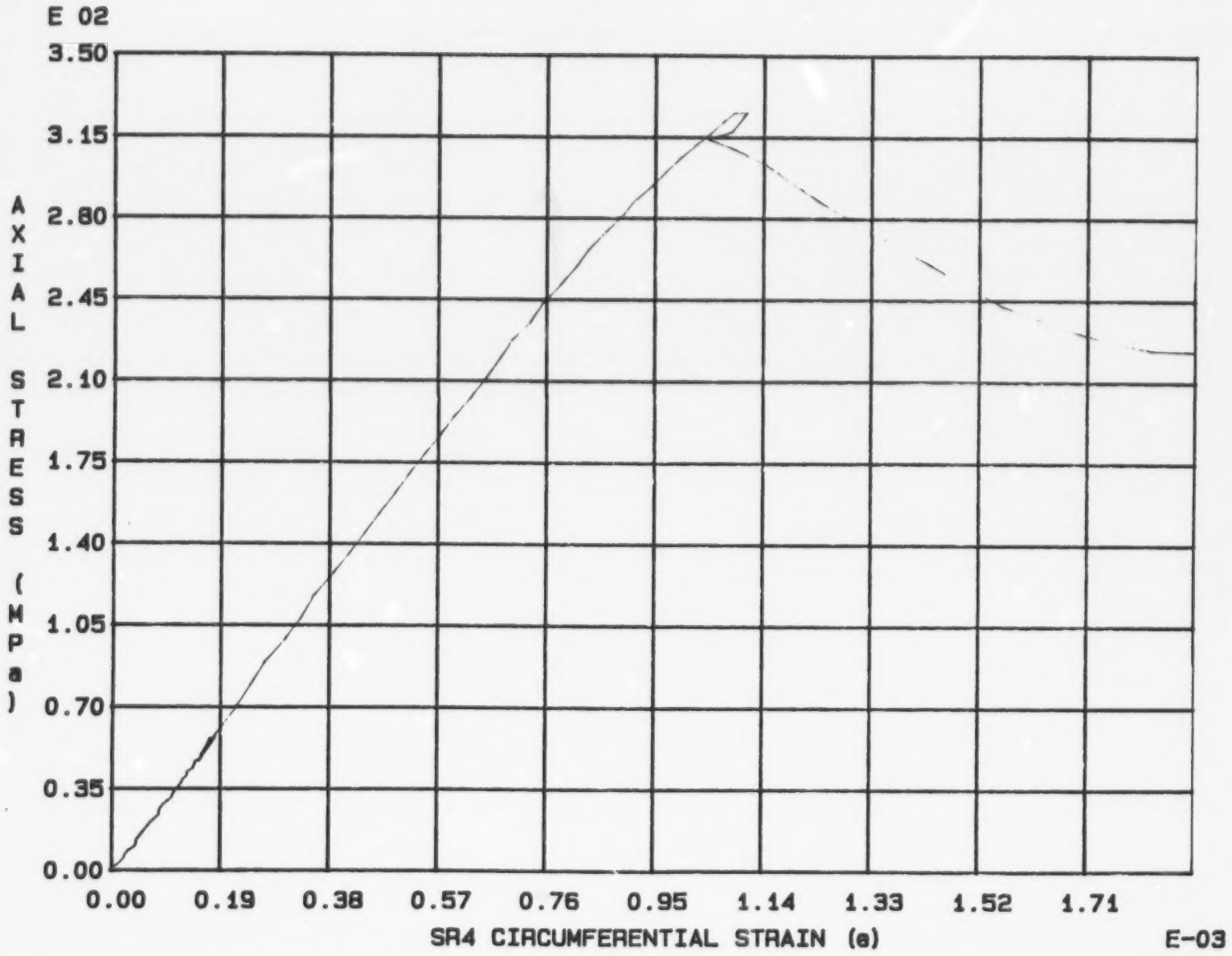

E 02
3.50
3.15
2.80
2.45
2.10
1.75
1.40
1.05
0.70
0.35
0.00
AXIAL STRESS (MPa)
0.00
0.19
0.38
0.57
0.76
0.95
1.14
1.33
1.52
1.71
SR4 CIRCUMFERENTIAL STRAIN (e)
E-03

Fig. D-29 E57U

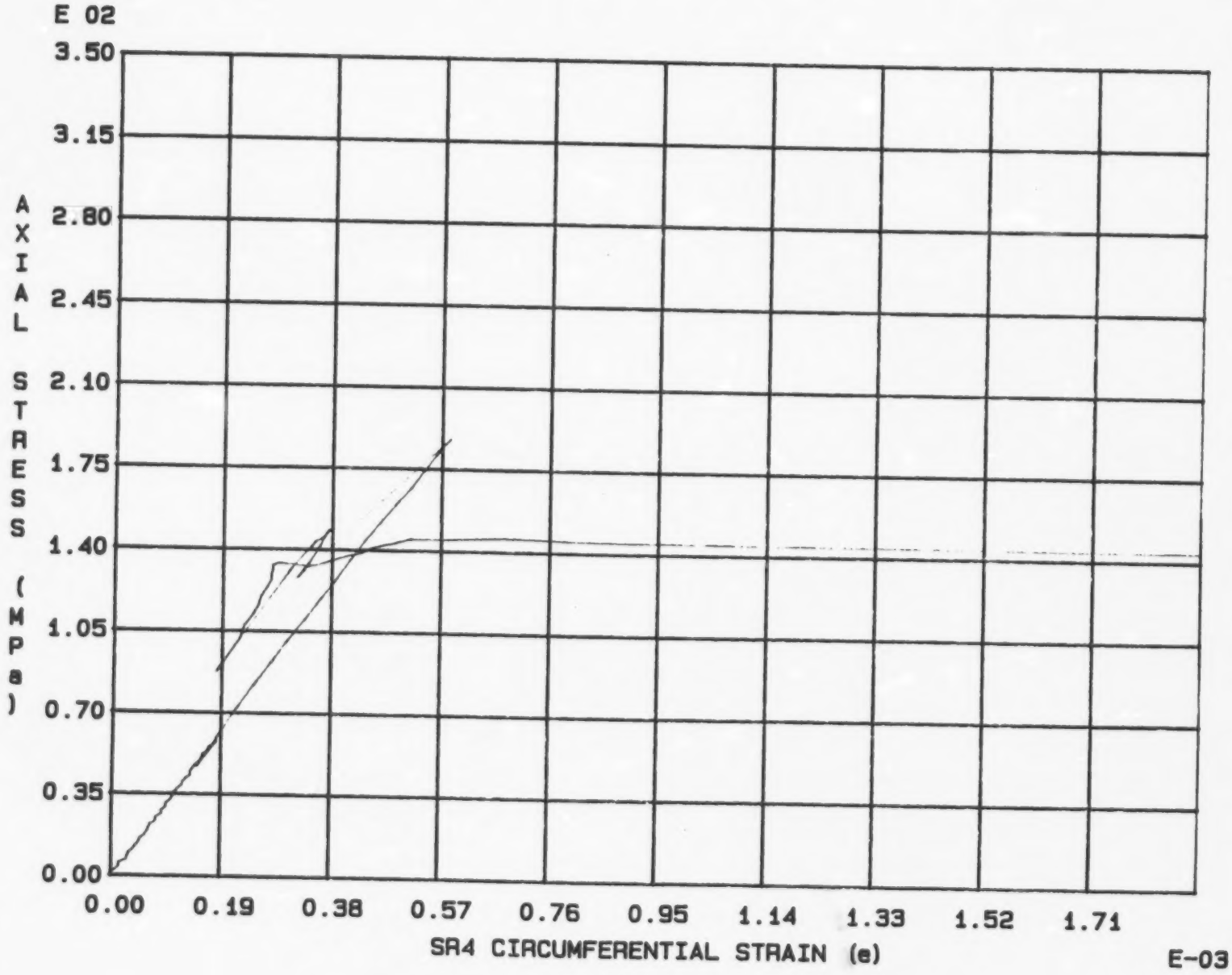

E 02
3.50
3.15
2.80
2.45
2.10
1.75
1.40
1.05
0.70
0.35
0.00
AXIAL STRESS (MPa)
0.00
0.19
0.38
0.57
0.76
0.95
1.14
1.33
1.52
1.71
SR4 CIRCUMFERENTIAL STRAIN (e)
E-03

Fig. D-30 E58U

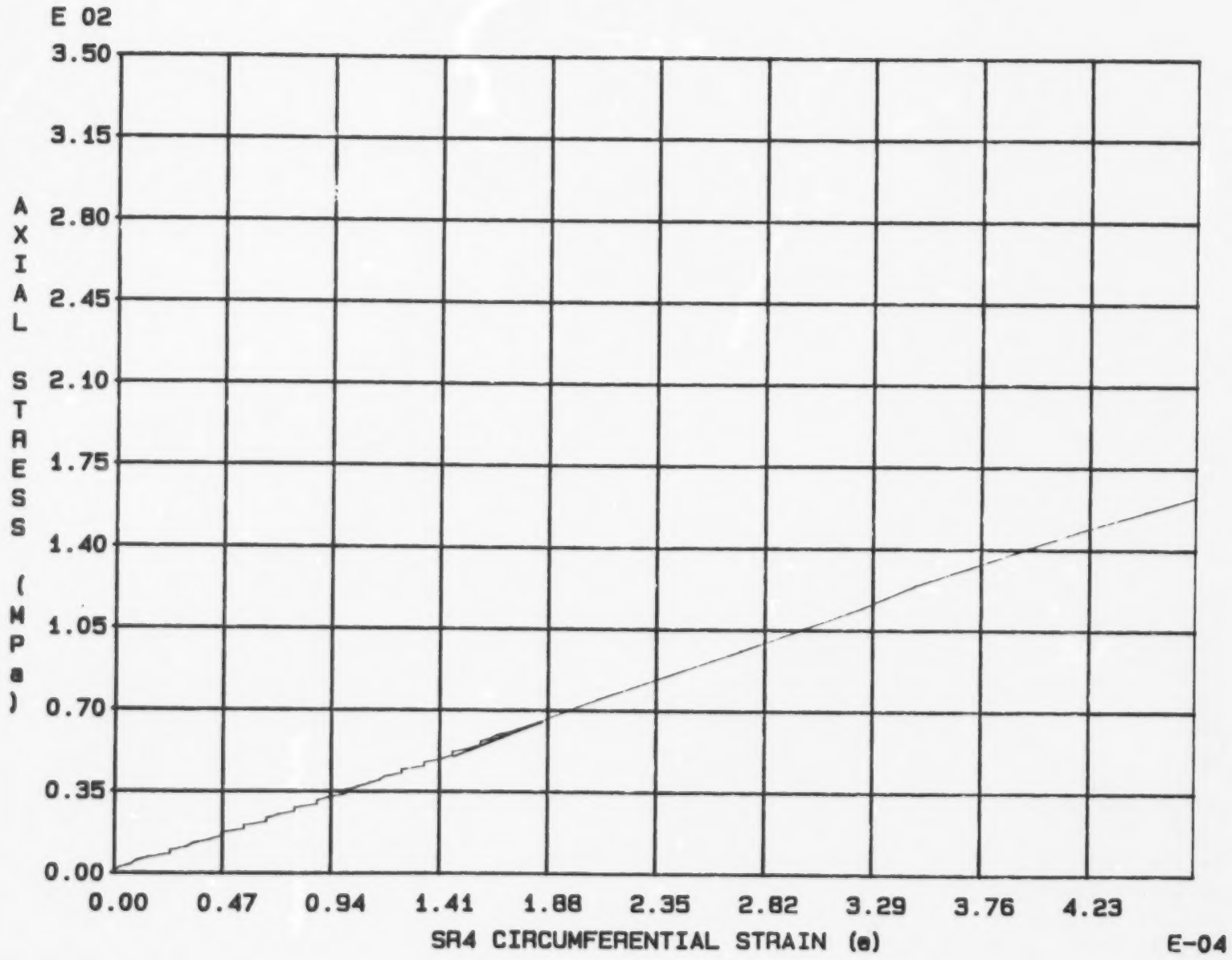

E 02
3.50
3.15
2.80
2.45
2.10
1.75
1.40
1.05
0.70
0.35
0.00
AXIAL STRESS (MPa)
0.00
0.47
0.94
1.41
1.88
2.35
2.82
3.29
3.76
4.23
SR4 CIRCUMFERENTIAL STRAIN (e)
E-04

Fig. D-31 E59U

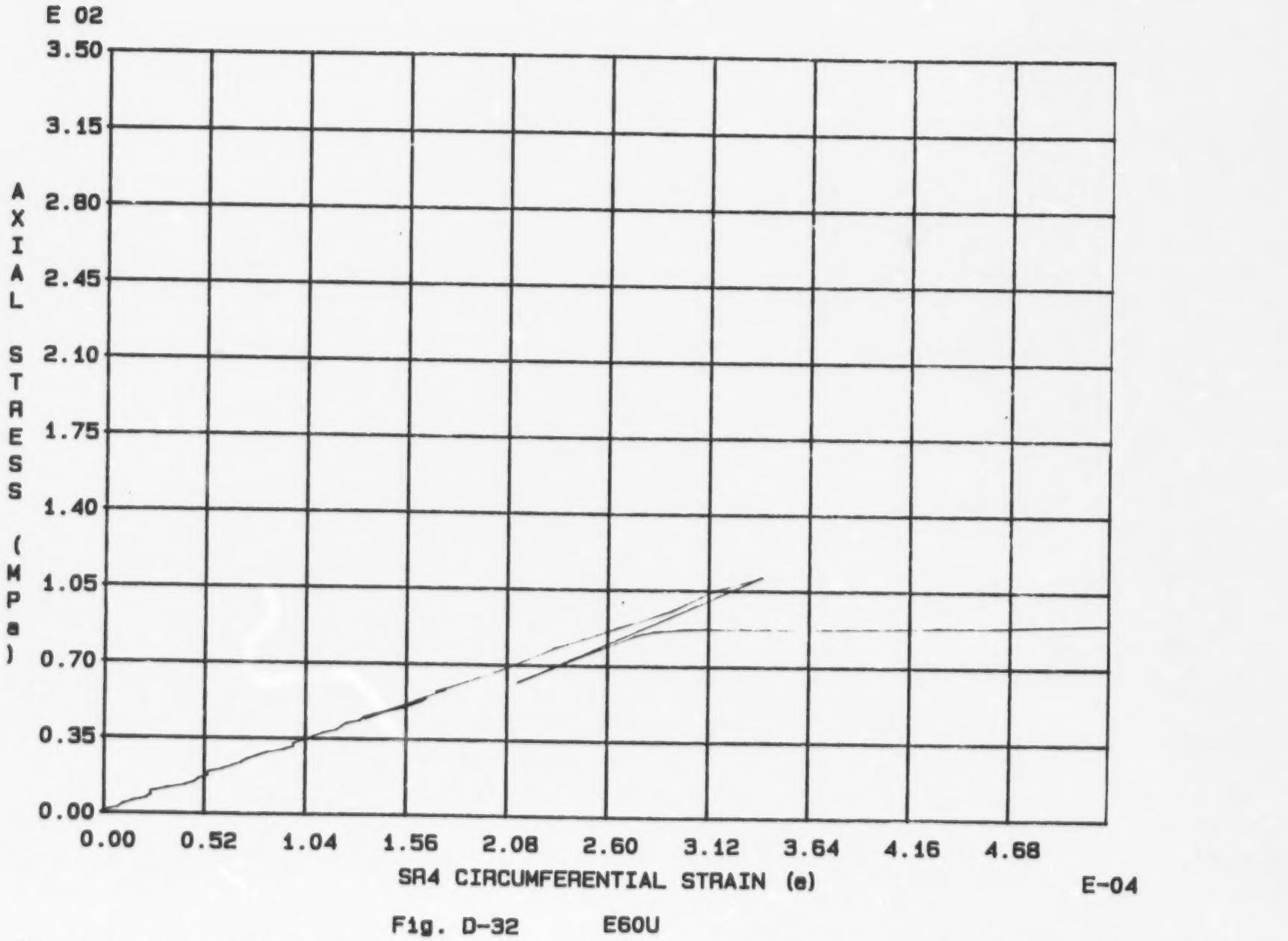

E 02
3.50
3.15
2.80
2.45
2.10
1.75
1.40
1.05
0.70
0.35
0.00
AXIAL STRESS (MPa)
0.00
0.52
1.04
1.56
2.08
2.60
3.12
3.64
4.16
4.68
SR4 CIRCUMFERENTIAL STRAIN (e)
E-04

Fig. D-32 E60U

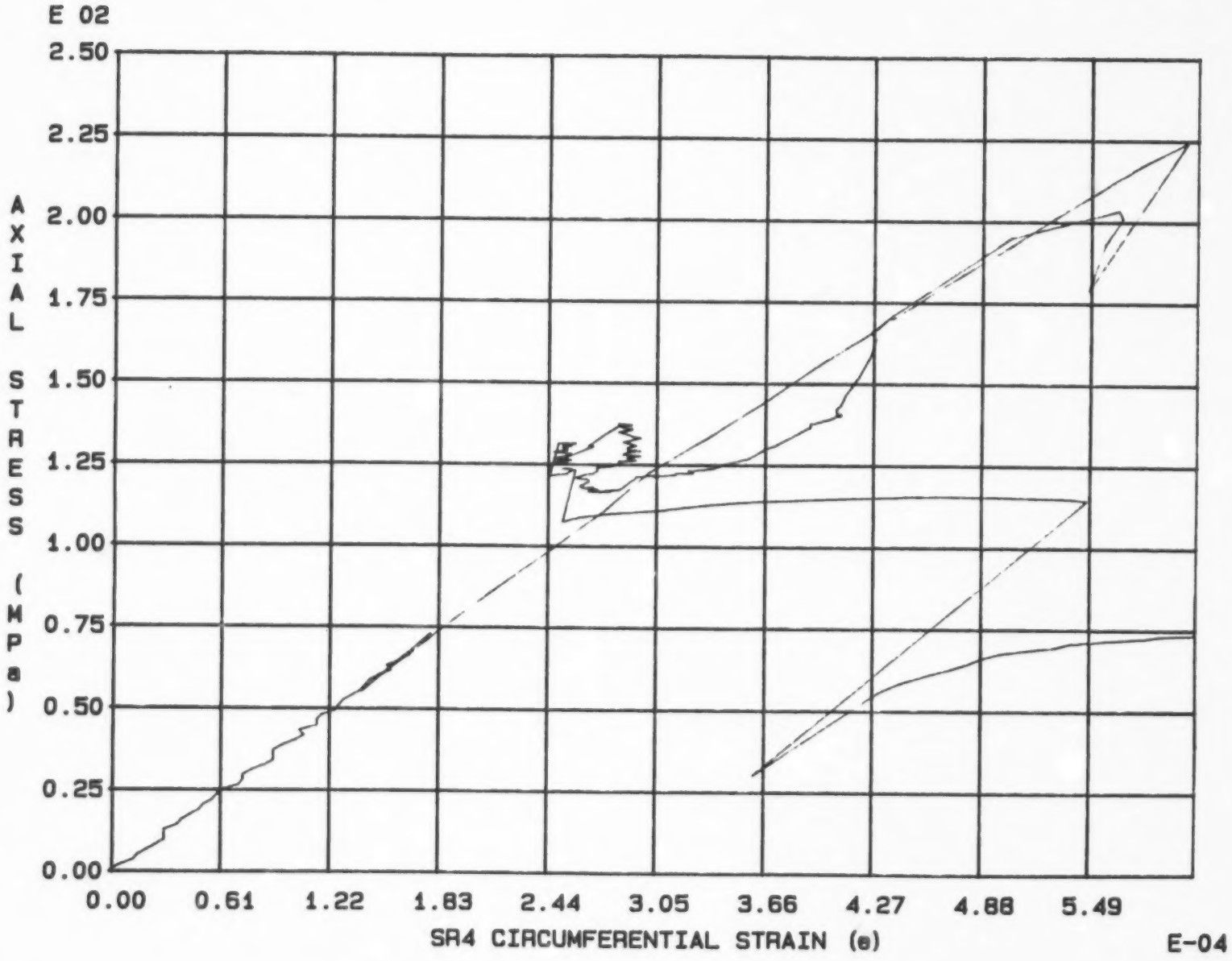

E 02
2.50
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
AXIAL STRESS (MPa)
0.00
0.61
1.22
1.83
2.44
3.05
3.66
4.27
4.88
5.49
SR4 CIRCUMFERENTIAL STRAIN (e)
E-04

Fig. D-33 E72U

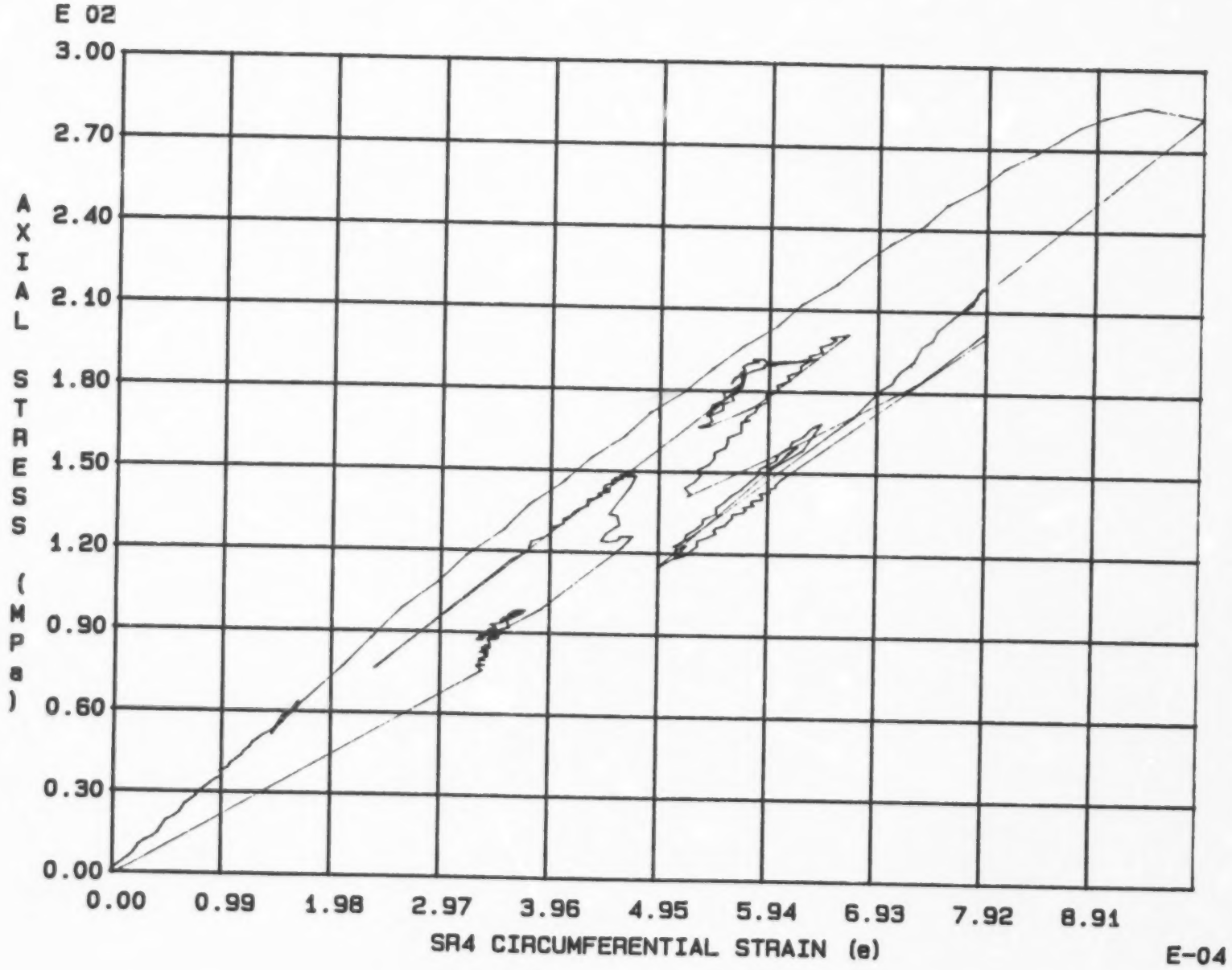

E 02
3.00
2.70
2.40
2.10
1.80
1.50
1.20
0.90
0.60
0.30
0.00
AXIAL STRESS (MPa)
0.00
0.99
1.98
2.97
3.96
4.95
5.94
6.93
7.92
8.91
SR4 CIRCUMFERENTIAL STRAIN (e)
E-04

Fig. D-34 E73U

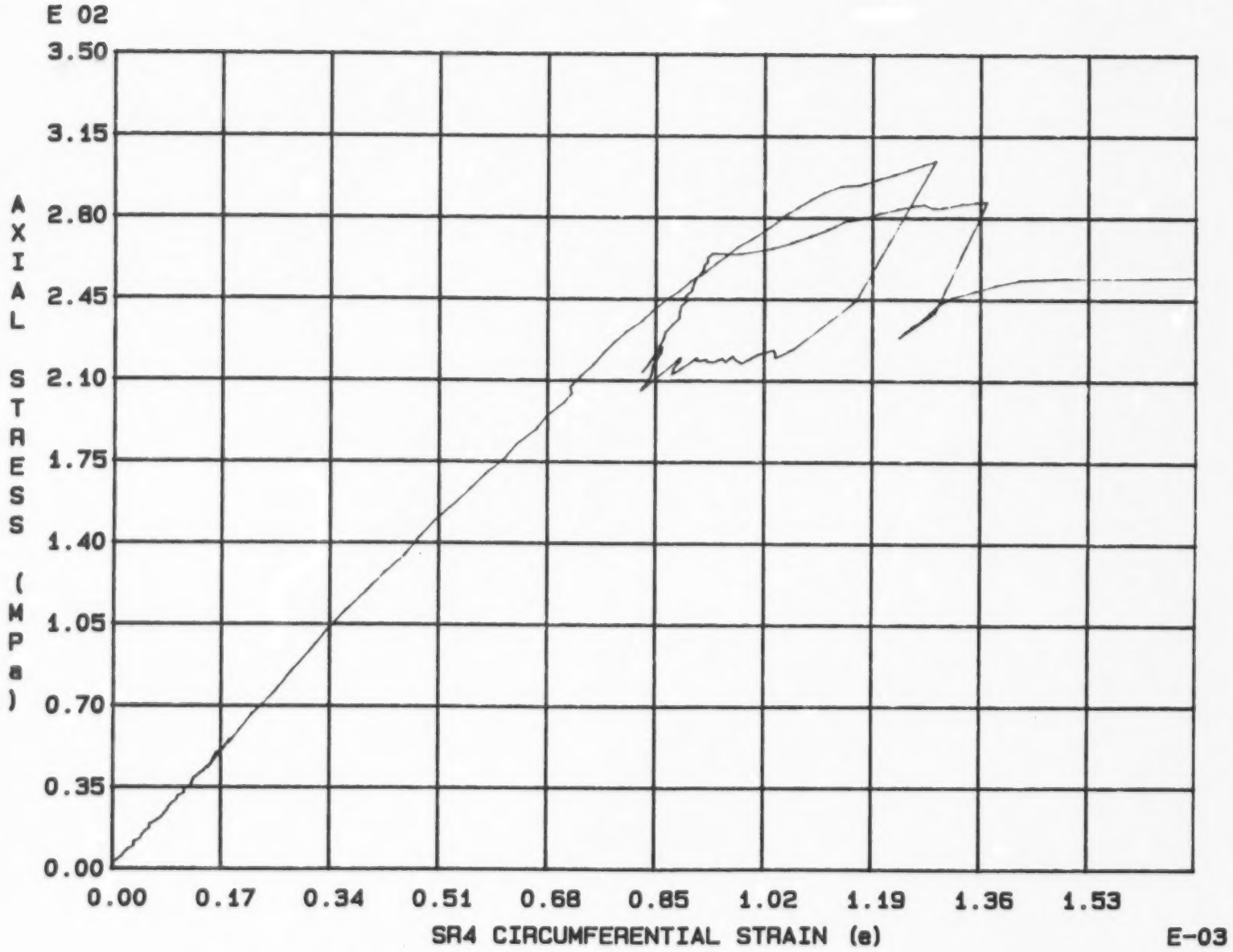

E 02
3.50
3.15
2.80
2.45
2.10
1.75
1.40
1.05
0.70
0.35
0.00
AXIAL STRESS (MPa)
0.00
0.17
0.34
0.51
0.68
0.85
1.02
1.19
1.36
1.53
SR4 CIRCUMFERENTIAL STRAIN (e)
E-03

Fig. D-35 E74U

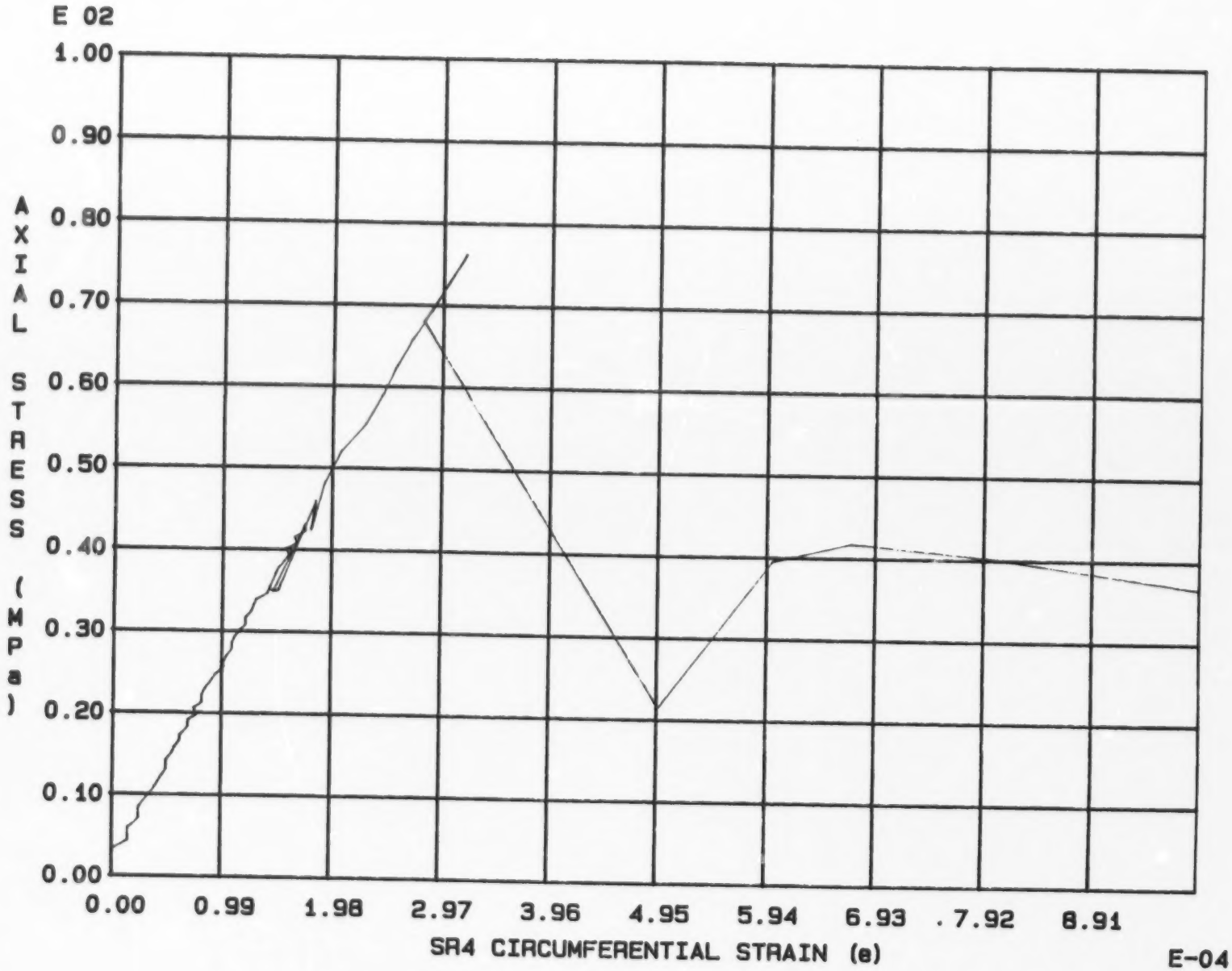

E 02
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
AXIAL STRESS (MPa)
0.00
0.99
1.98
2.97
3.96
4.95
5.94
6.93
7.92
8.91
SR4 CIRCUMFERENTIAL STRAIN (e)
E-04

Fig. D-36 E75U

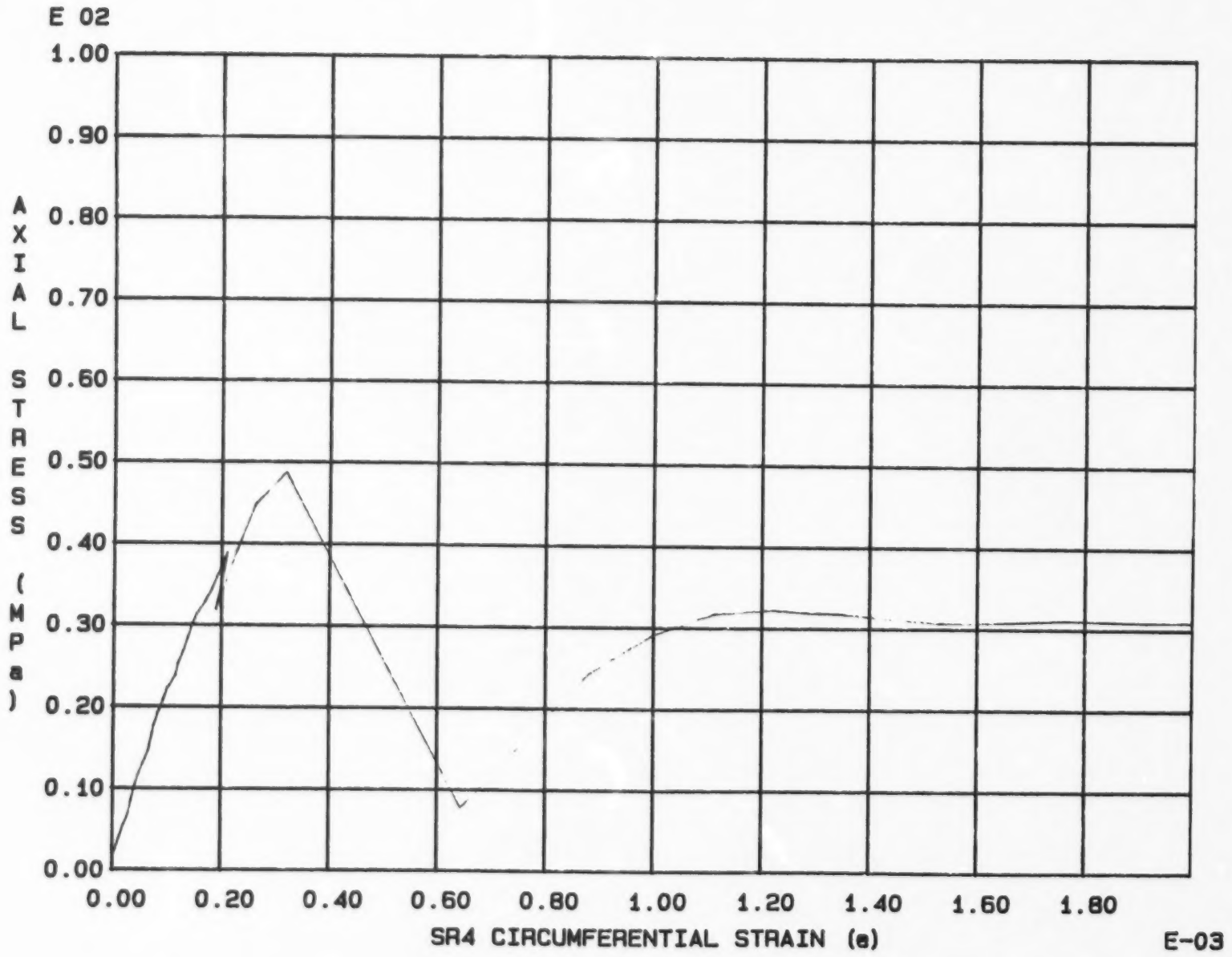

E 02
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
AXIAL STRESS (MPa)
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
1.60
1.80
SR4 CIRCUMFERENTIAL STRAIN (e)
E-03

Fig. D-37 E76U

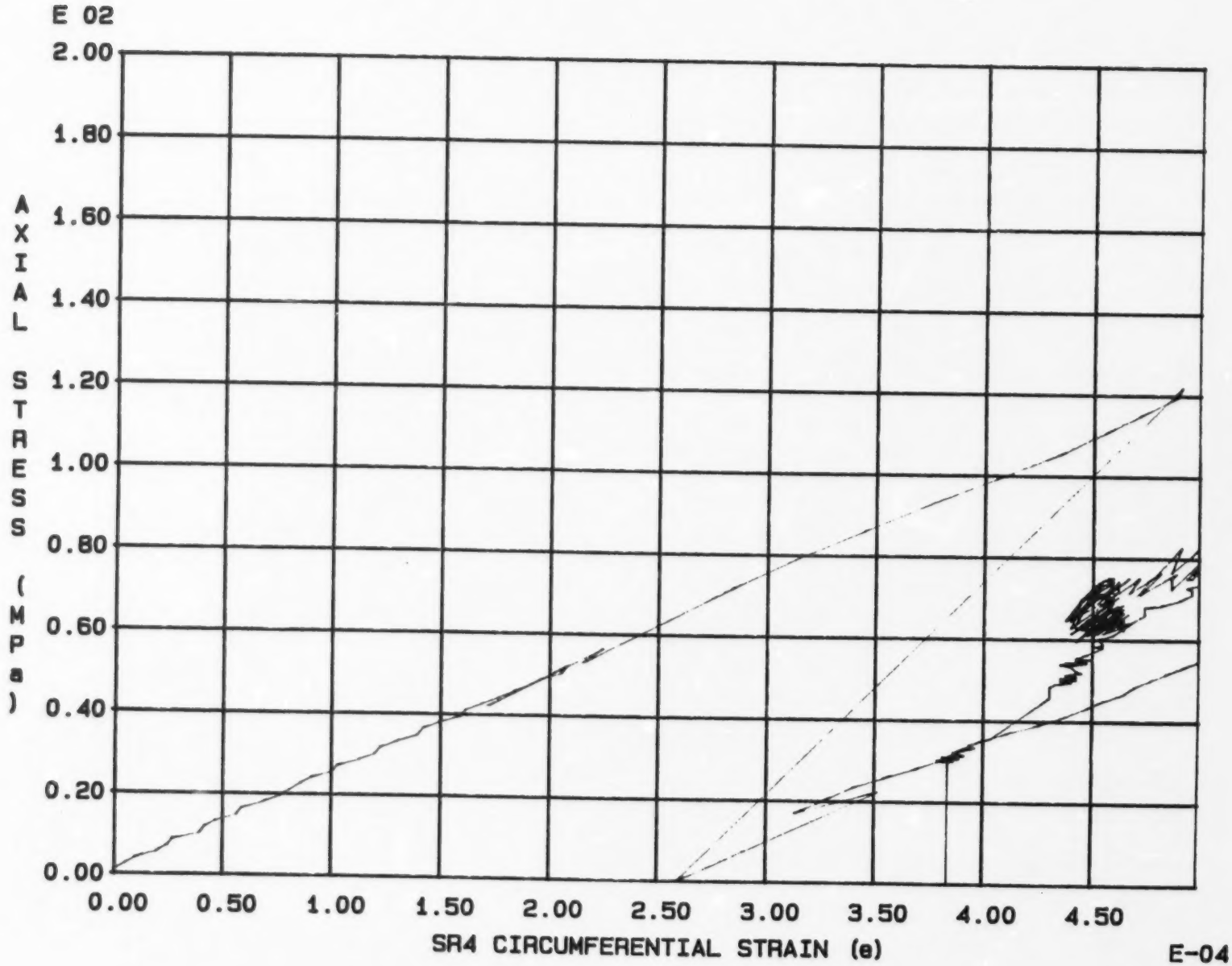

E 02
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
AXIAL STRESS (MPa)
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
SR4 CIRCUMFERENTIAL STRAIN (e)
E-04

Fig. D-38 E77U

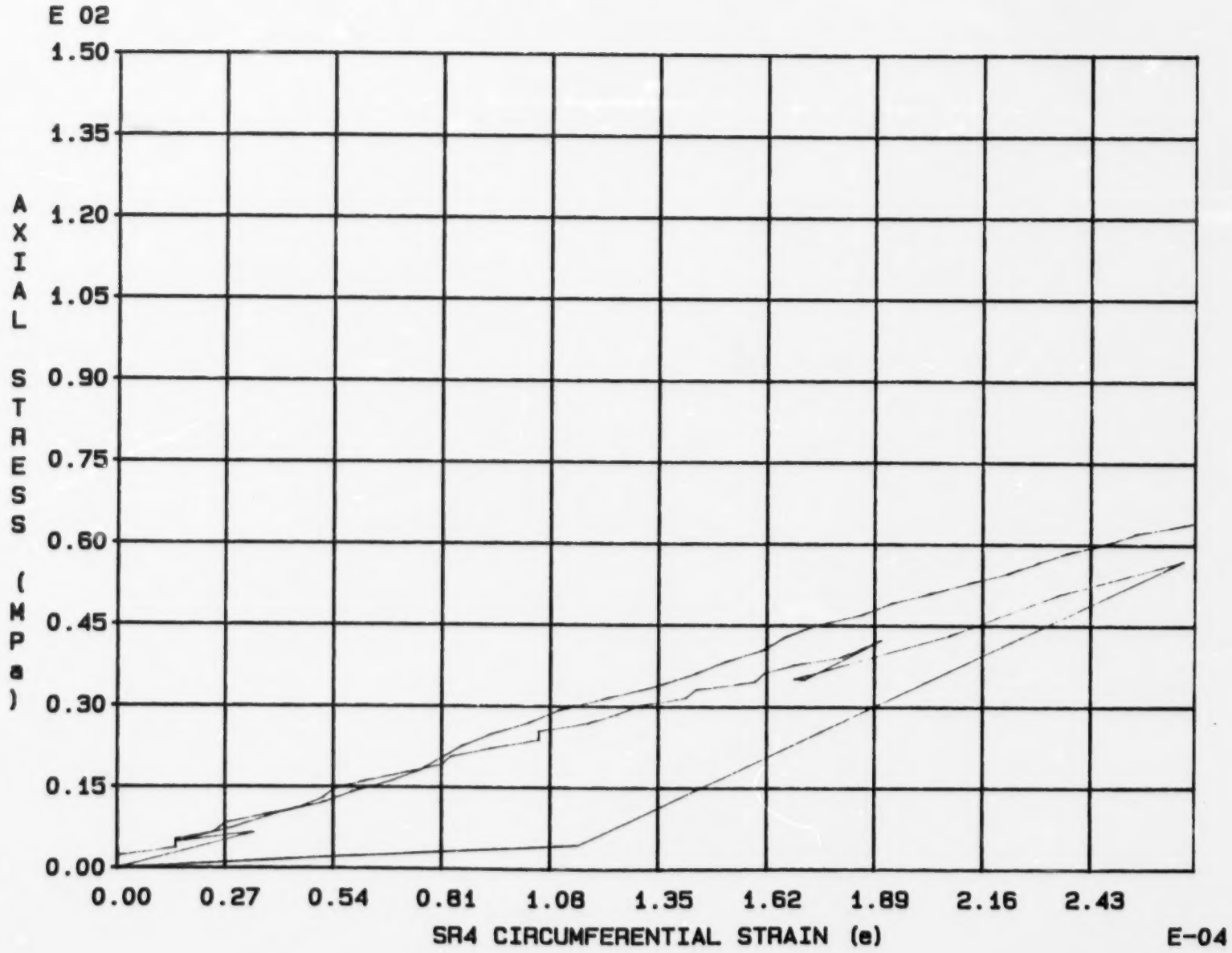

E 02
1.50
1.35
1.20
1.05
0.90
0.75
0.60
0.45
0.30
0.15
0.00
AXIAL STRESS (MPa)
0.00
0.27
0.54
0.81
1.08
1.35
1.62
1.89
2.16
2.43
SR4 CIRCUMFERENTIAL STRAIN (e)
E-04

Fig. D-39 E78U

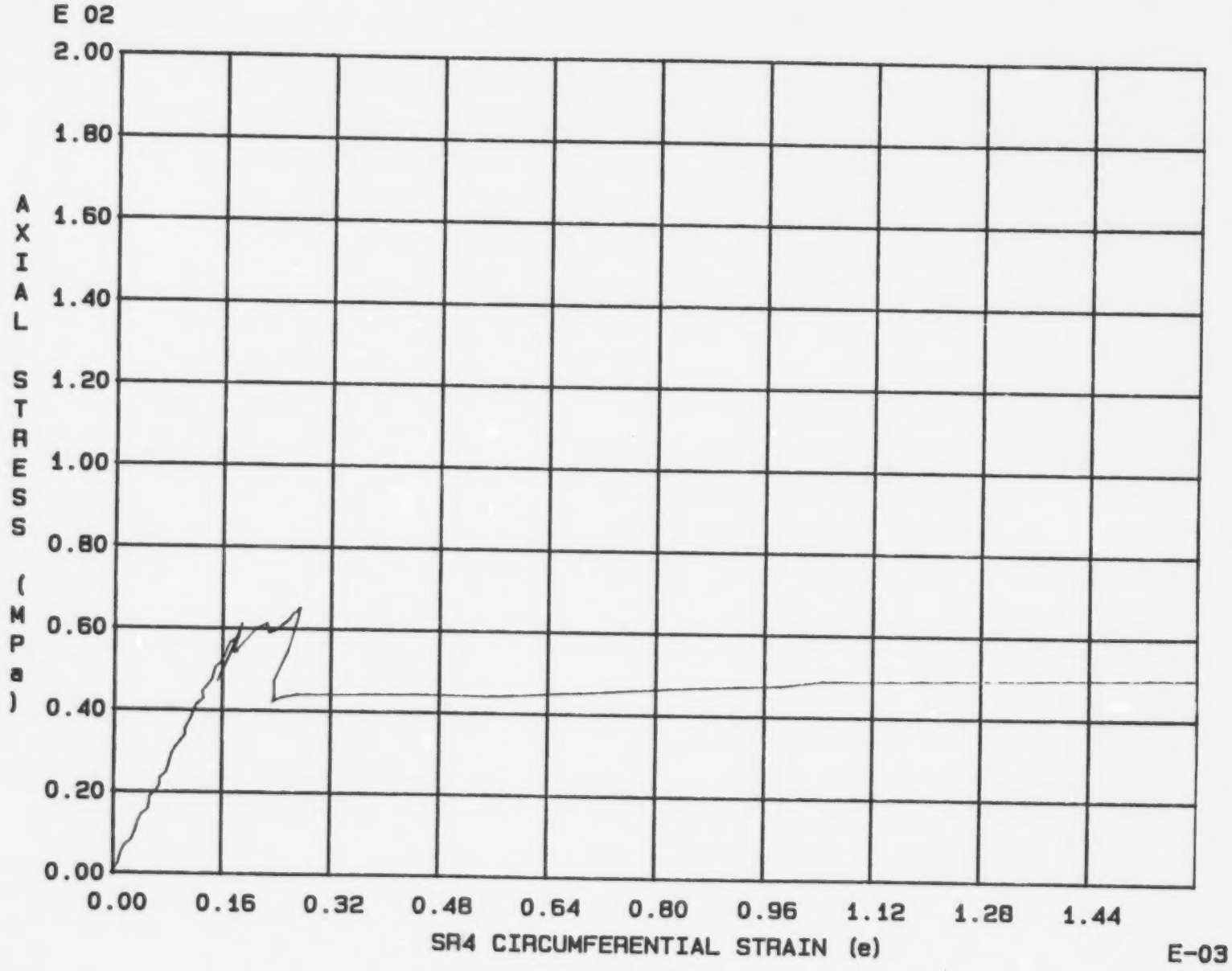

E 02
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
AXIAL STRESS (MPa)
0.00
0.16
0.32
0.48
0.64
0.80
0.96
1.12
1.28
1.44
SR4 CIRCUMFERENTIAL STRAIN (e)
E-03

Fig. D-40 E79U

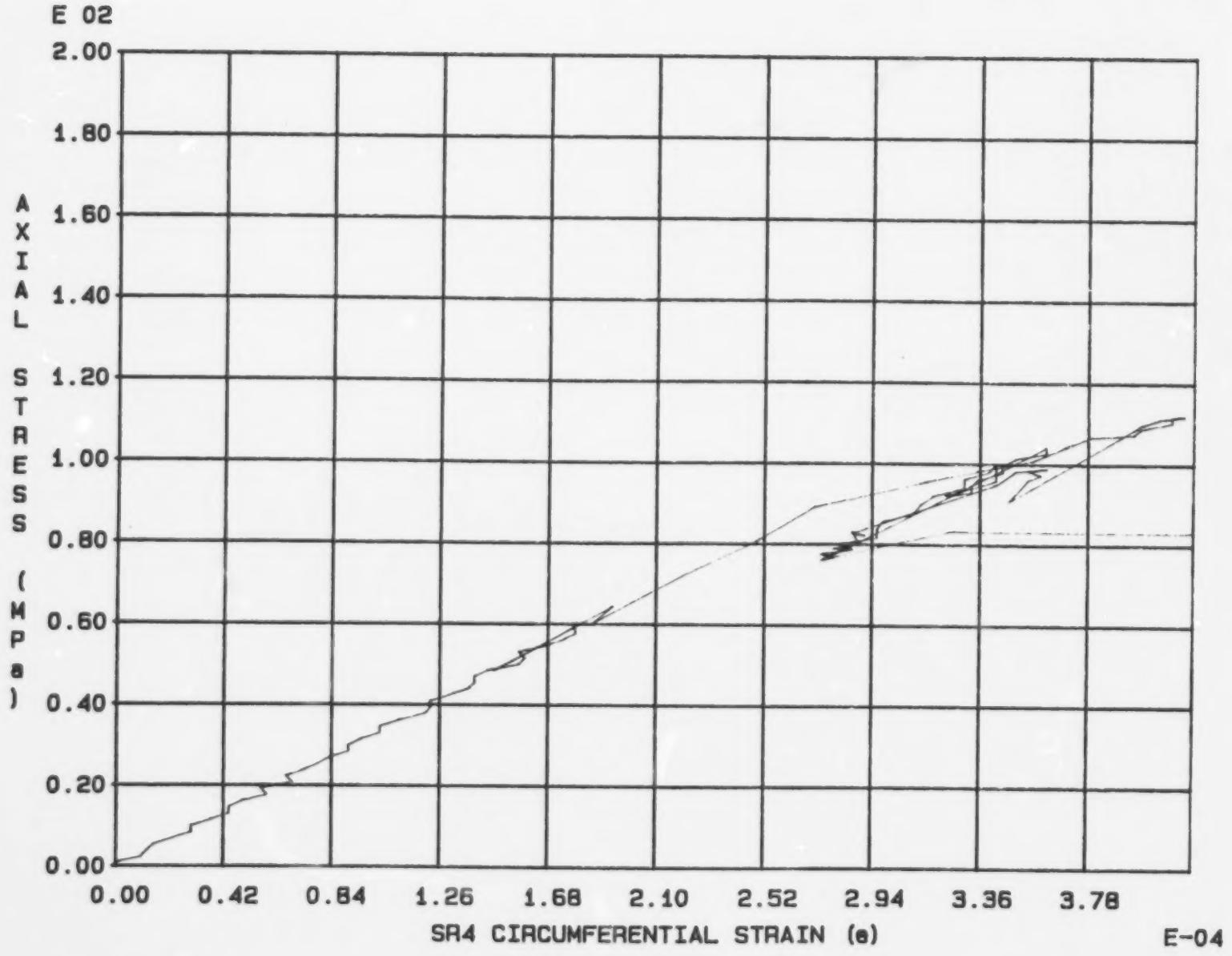

E 02
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
AXIAL STRESS (MPa)
0.00
0.42
0.84
1.26
1.68
2.10
2.52
2.94
3.36
3.78
SR4 CIRCUMFERENTIAL STRAIN (e)
E-04

Fig. D-41 E80U

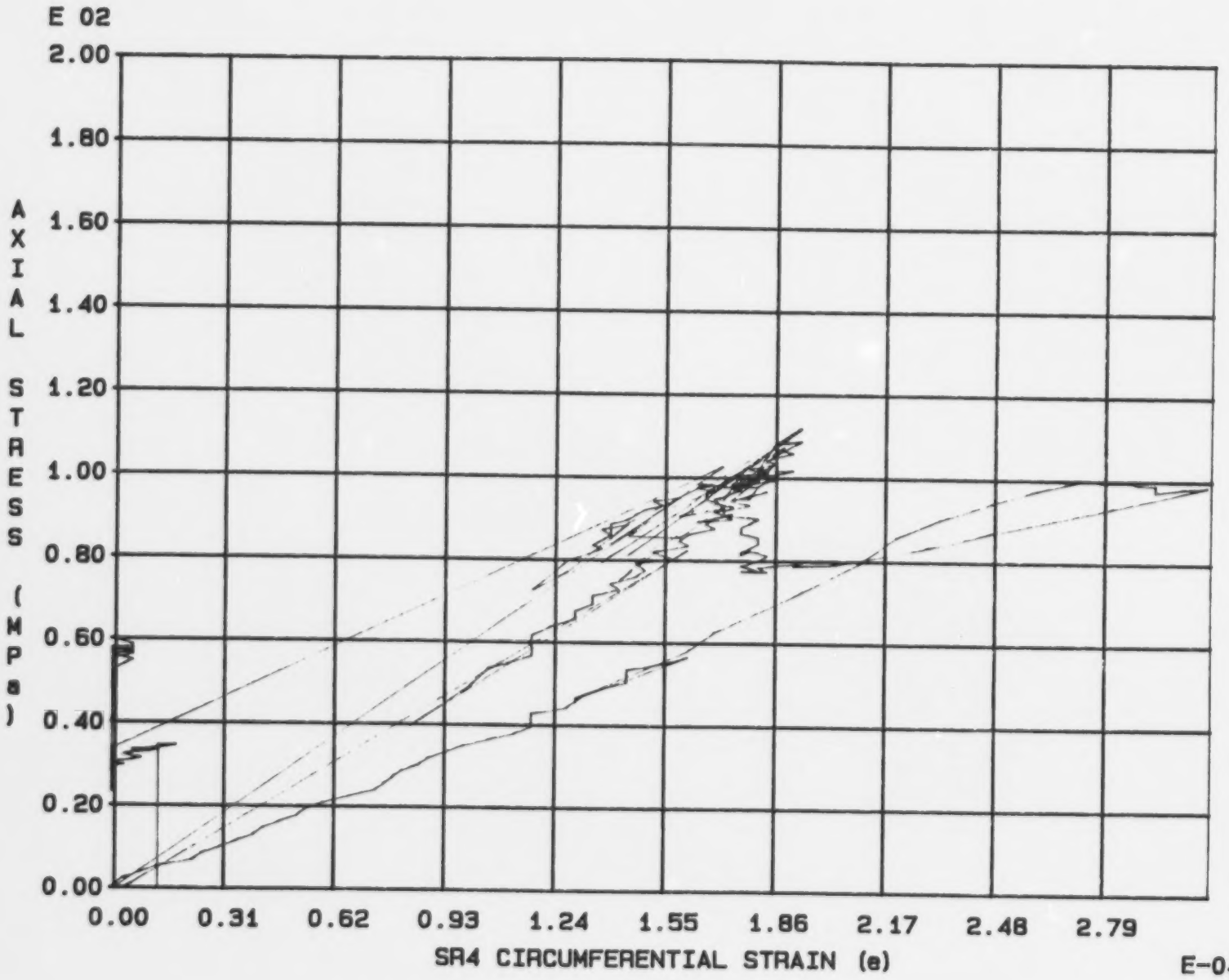

E 02
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
AXIAL STRESS (MPa)
0.00
0.31
0.62
0.93
1.24
1.55
1.86
2.17
2.48
2.79
SR4 CIRCUMFERENTIAL STRAIN (e)
E-04

Fig. D-42 E81U

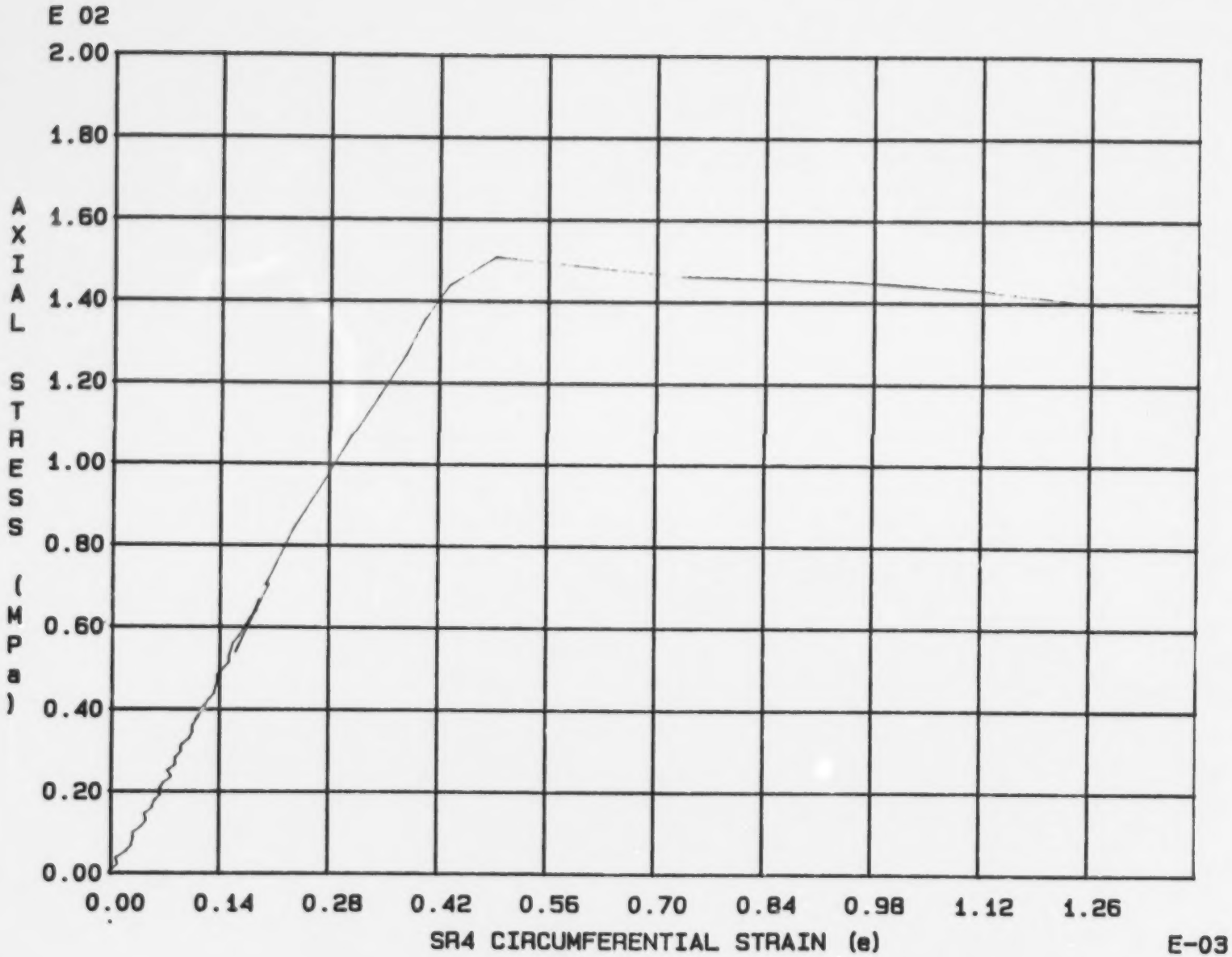

E 02
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
AXIAL STRESS (MPa)
0.00
0.14
0.28
0.42
0.56
0.70
0.84
0.98
1.12
1.26
SR4 CIRCUMFERENTIAL STRAIN (e)
E-03

Fig. D-43 E82U

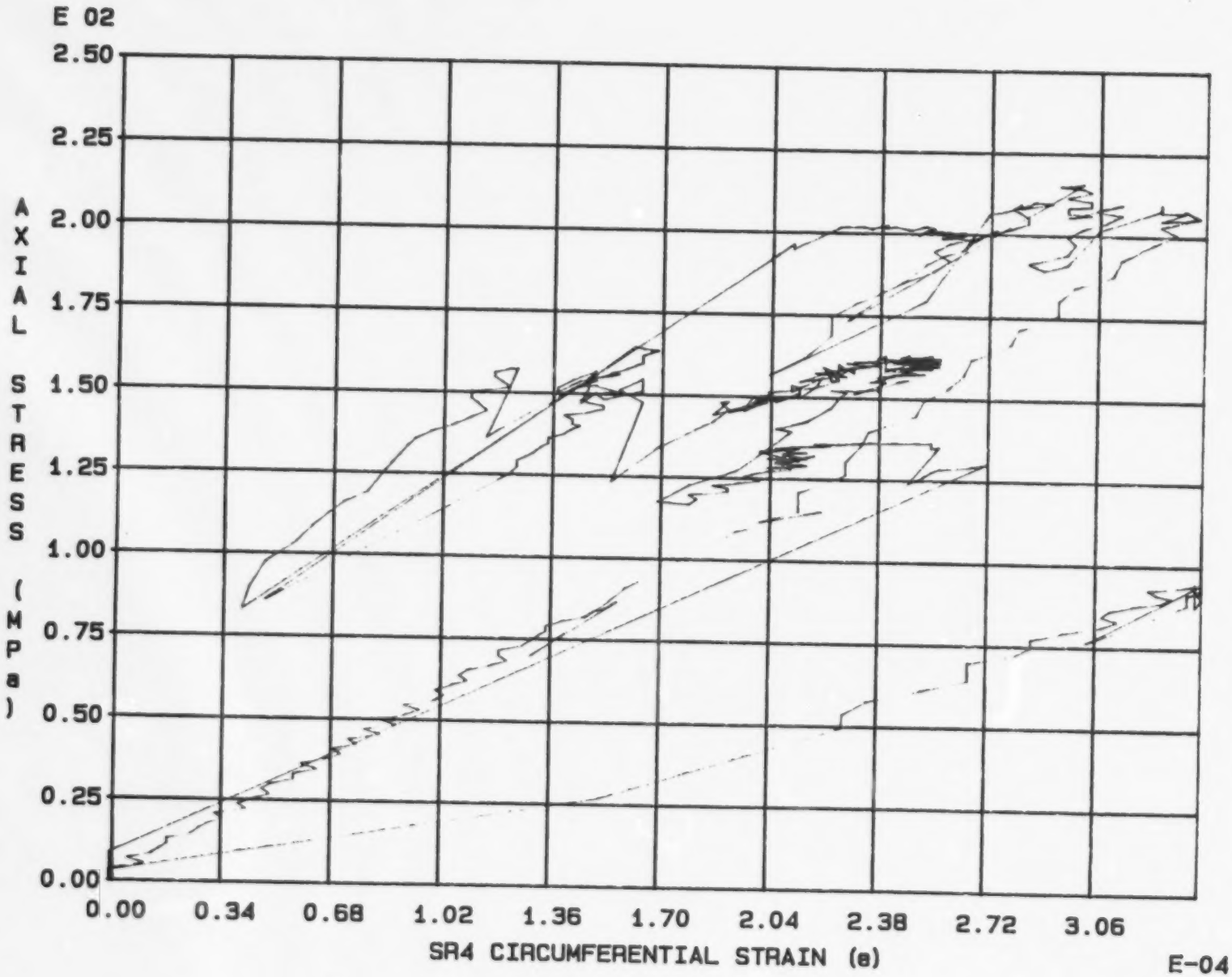

E 02
2.50
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
AXIAL STRESS (MPa)
0.00
0.34
0.68
1.02
1.36
1.70
2.04
2.38
2.72
3.06
SR4 CIRCUMFERENTIAL STRAIN (e)
E-04

Fig. D-44 E83U

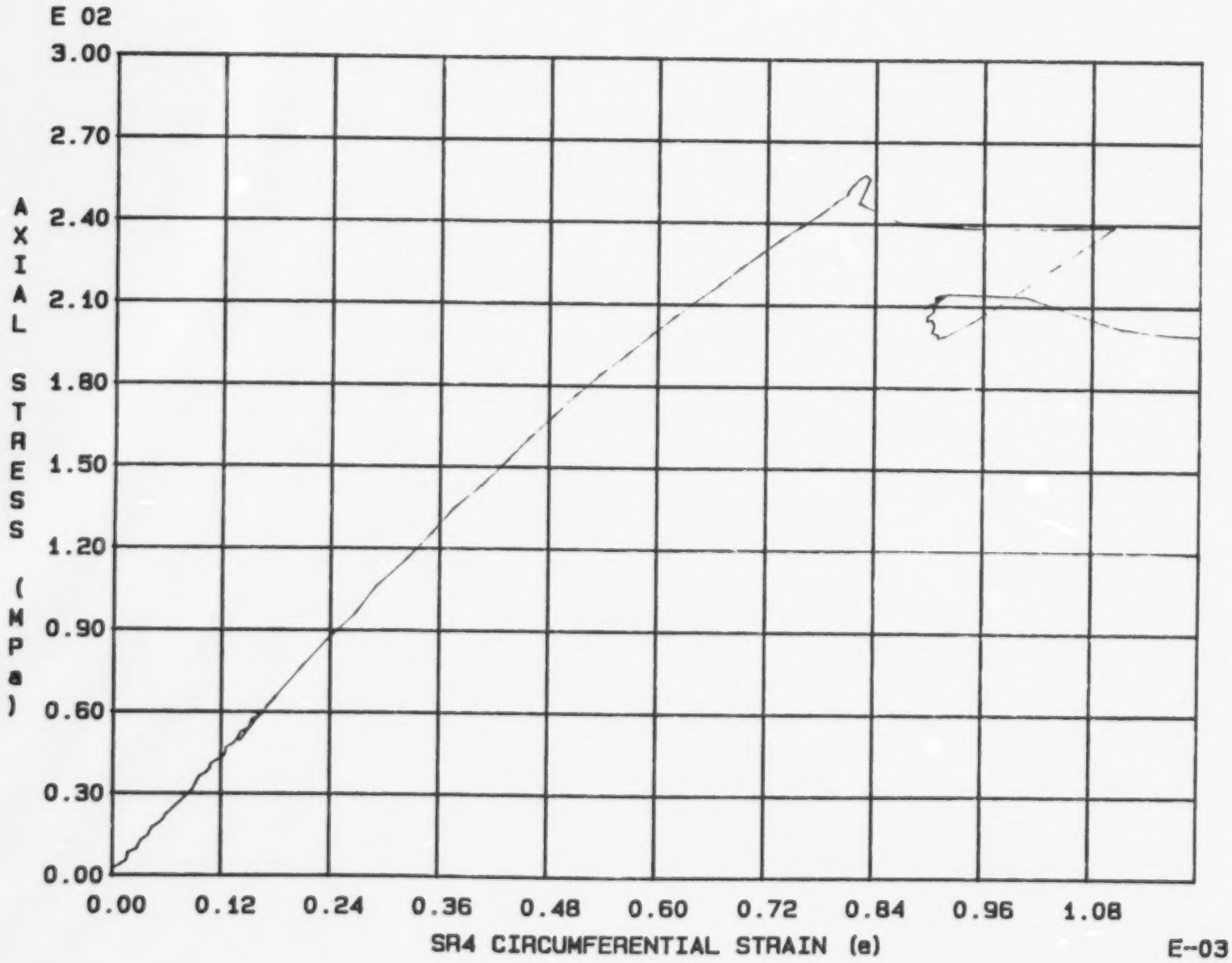

E 02
3.00
2.70
2.40
2.10
1.80
1.50
1.20
0.90
0.60
0.30
0.00
AXIAL STRESS (MPa)
0.00
0.12
0.24
0.36
0.48
0.60
0.72
0.84
0.96
1.08
SR4 CIRCUMFERENTIAL STRAIN (e)
E-03

Fig. D-45 E84U

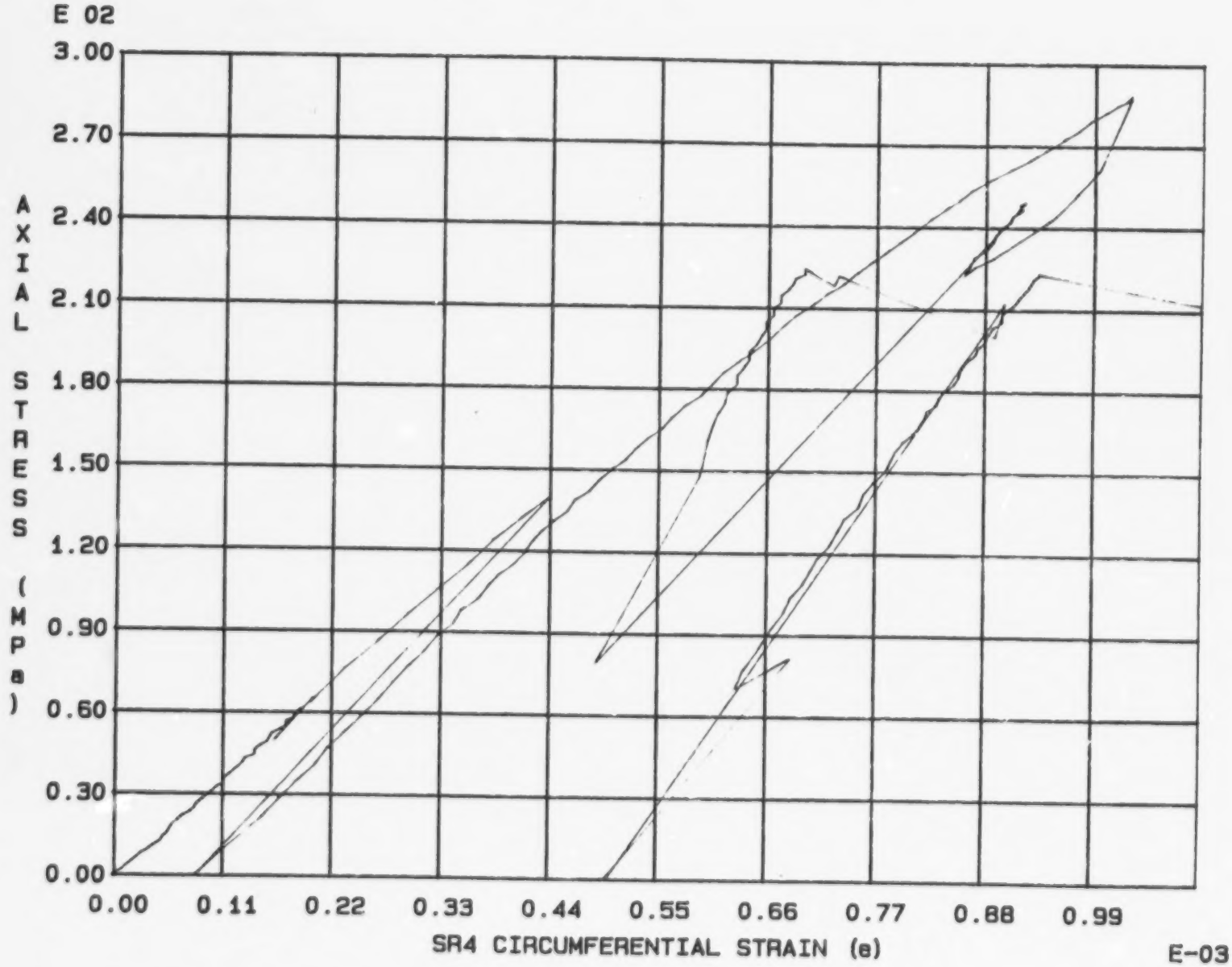

E 02
3.00
2.70
2.40
2.10
1.80
1.50
1.20
0.90
0.60
0.30
0.00
AXIAL STRESS (MPa)
0.00
0.11
0.22
0.33
0.44
0.55
0.66
0.77
0.88
0.99
SR4 CIRCUMFERENTIAL STRAIN (e)
E-03

Fig. D-46 E85U

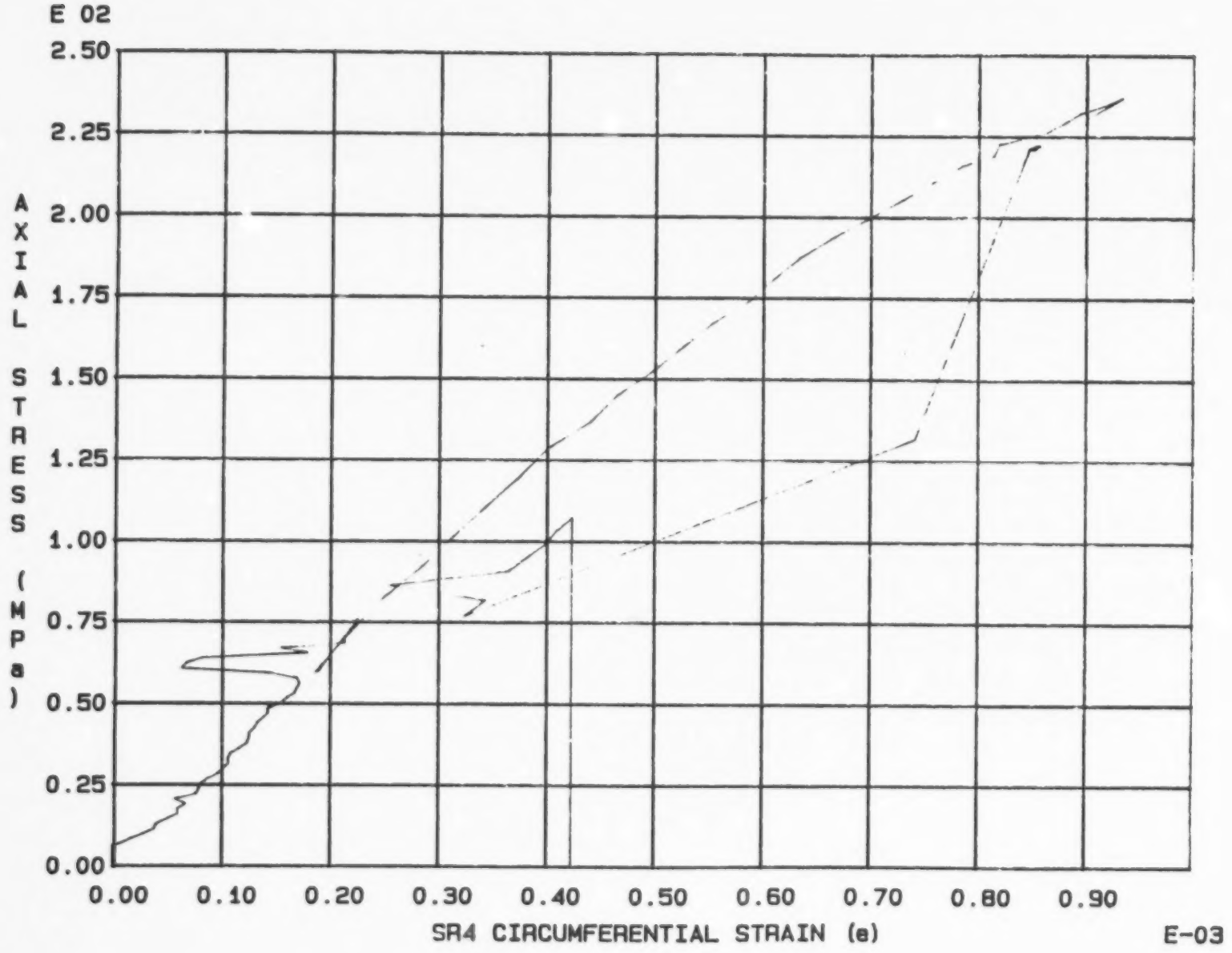

E 02
2.50
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
AXIAL STRESS (MPa)
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
SR4 CIRCUMFERENTIAL STRAIN (e)
E-03

Fig. D-47 E86U

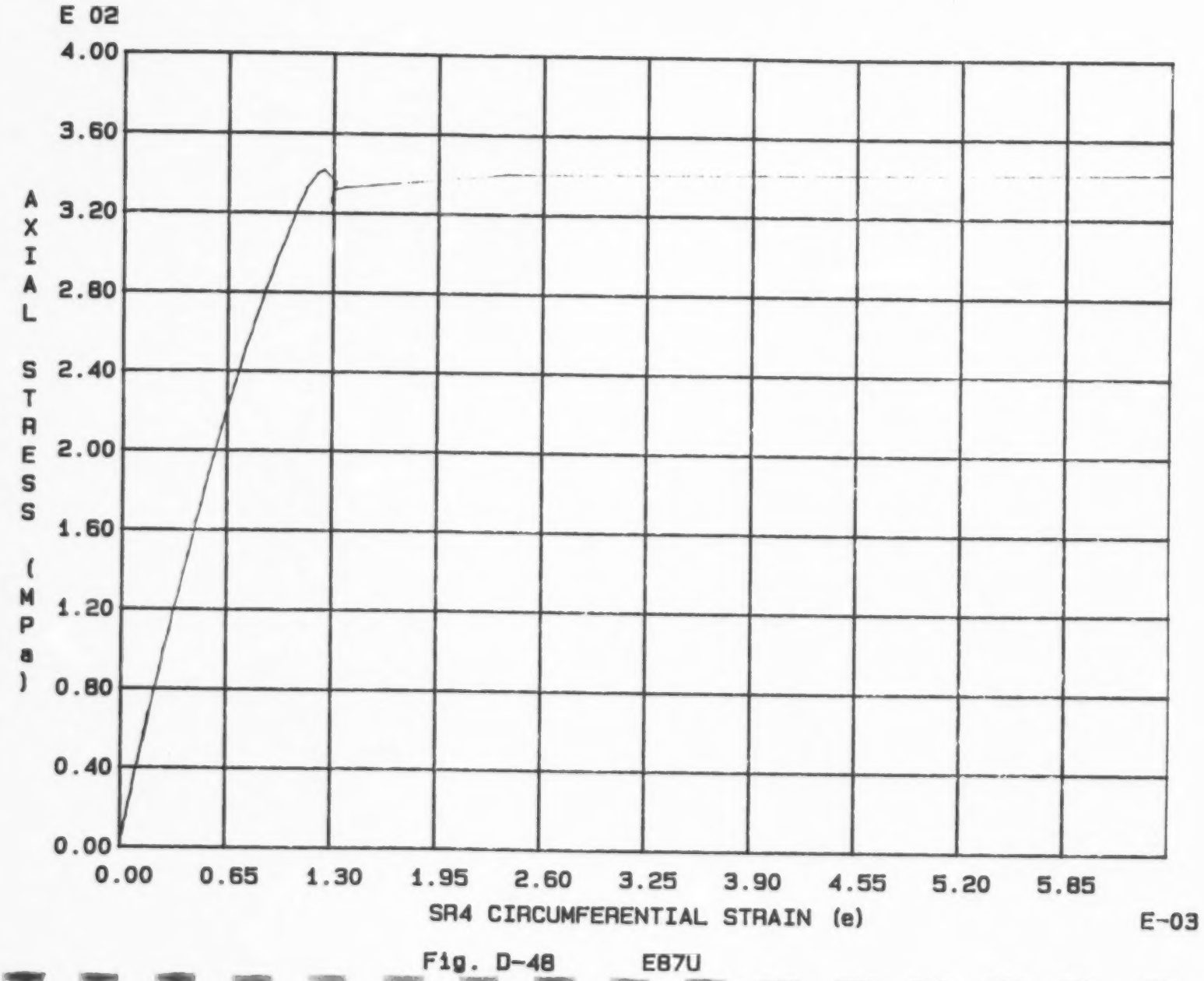

E 02
4.00
3.60
3.20
2.80
2.40
2.00
1.60
1.20
0.80
0.40
0.00
AXIAL STRESS (MPa)
0.00
0.65
1.30
1.95
2.60
3.25
3.90
4.55
5.20
5.85
SR4 CIRCUMFERENTIAL STRAIN (e)
E-03

Fig. D-48 E87U

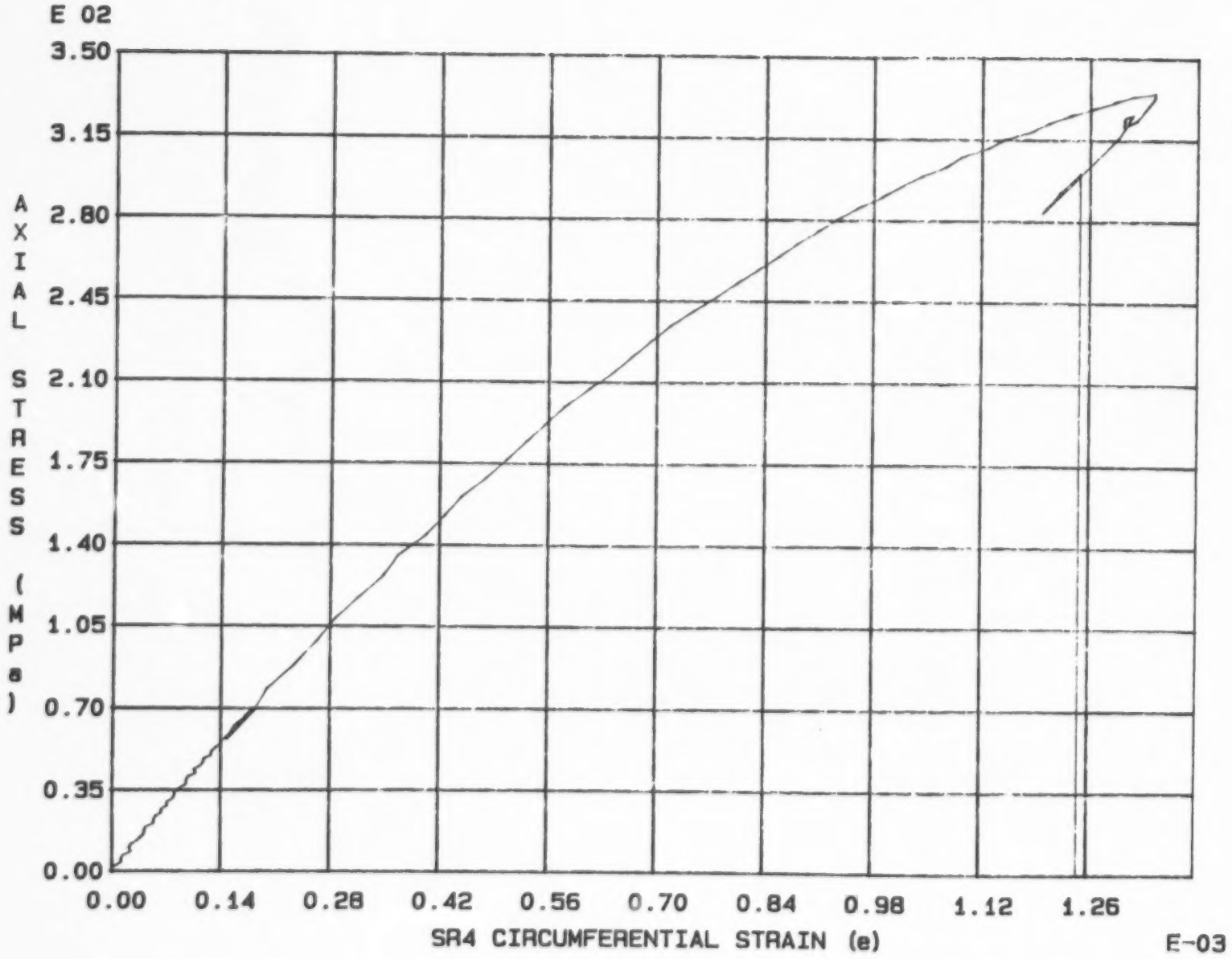

E 02
3.50
3.15
2.80
2.45
2.10
1.75
1.40
1.05
0.70
0.35
0.00
AXIAL STRESS (MPa)
0.00
0.14
0.28
0.42
0.56
0.70
0.84
0.98
1.12
1.26
SR4 CIRCUMFERENTIAL STRAIN (e)
E-03

Fig. D-49 E88U

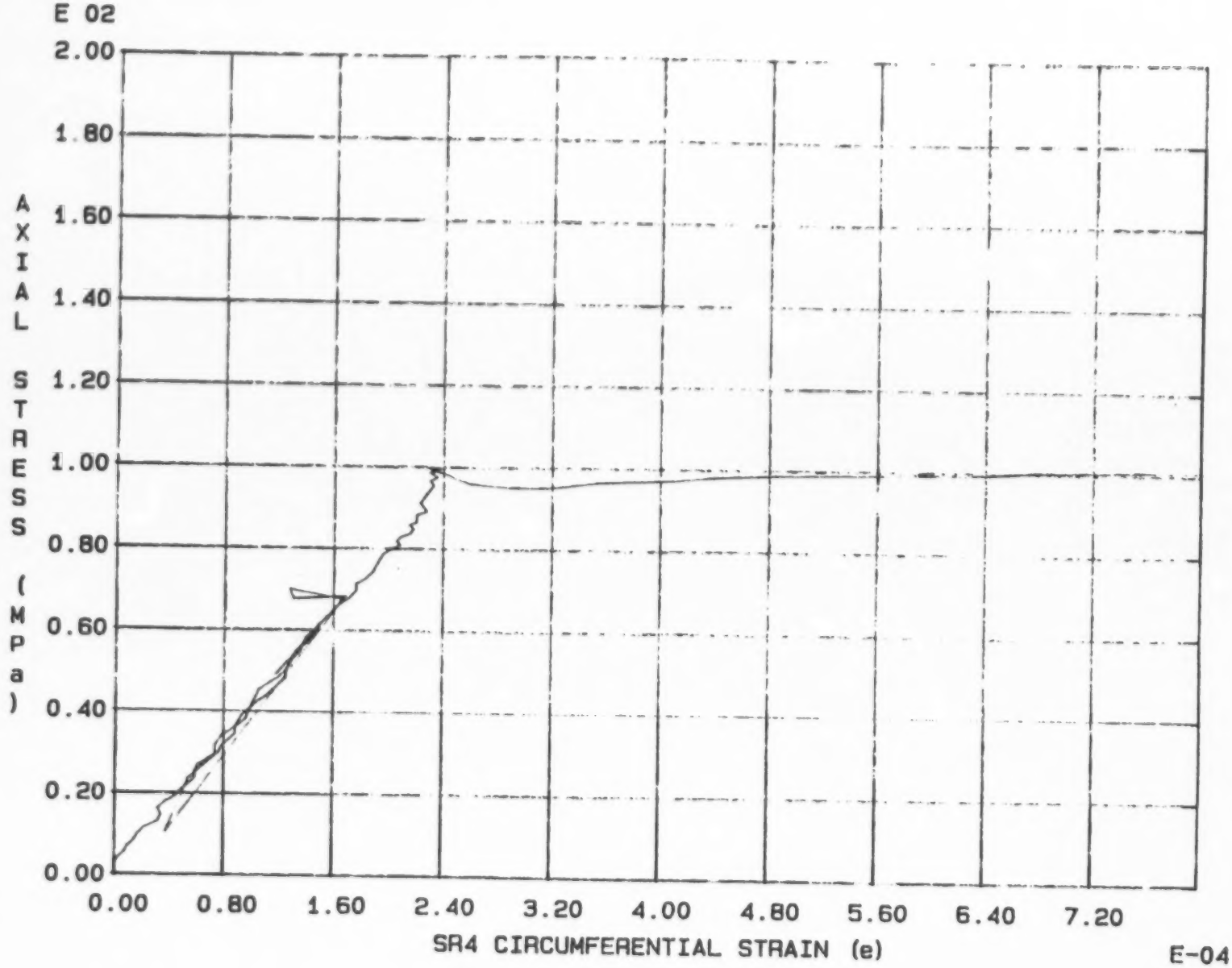

E 02
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
AXIAL STRESS (MPa)
0.00
0.80
1.60
2.40
3.20
4.00
4.80
5.60
6.40
7.20
SR4 CIRCUMFERENTIAL STRAIN (e)
E-04

Fig. D-50 E89U

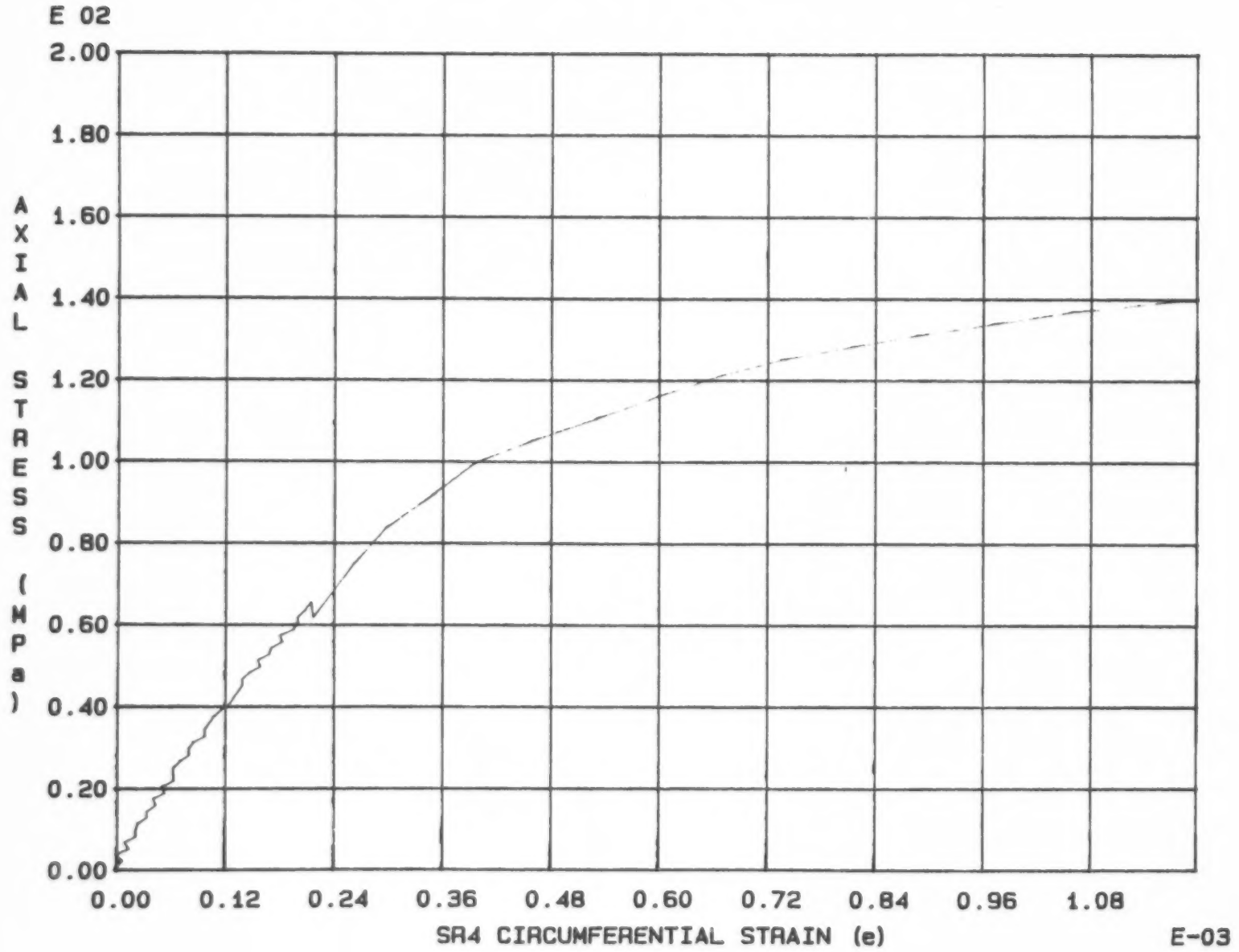

E 02
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
AXIAL STRESS (MPa)
0.00
0.12
0.24
0.36
0.48
0.60
0.72
0.84
0.96
1.08
SR4 CIRCUMFERENTIAL STRAIN (e)
E-03

Fig. D-51 E90U

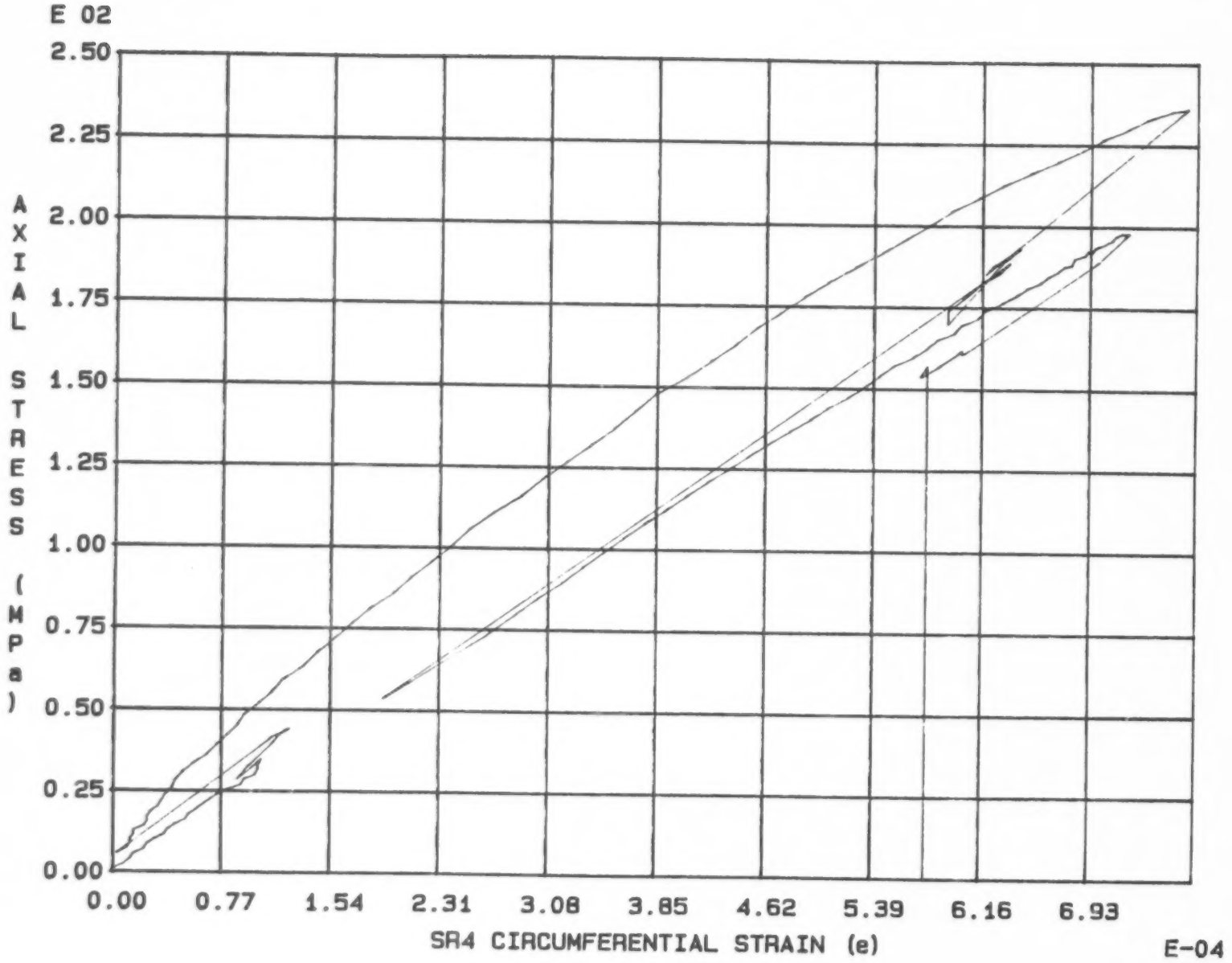

E 02
2.50
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
AXIAL STRESS (MPa)
0.00
0.77
1.54
2.31
3.08
3.85
4.62
5.39
6.16
6.93
SR4 CIRCUMFERENTIAL STRAIN (e)
E-04

Fig. D-52 E91U

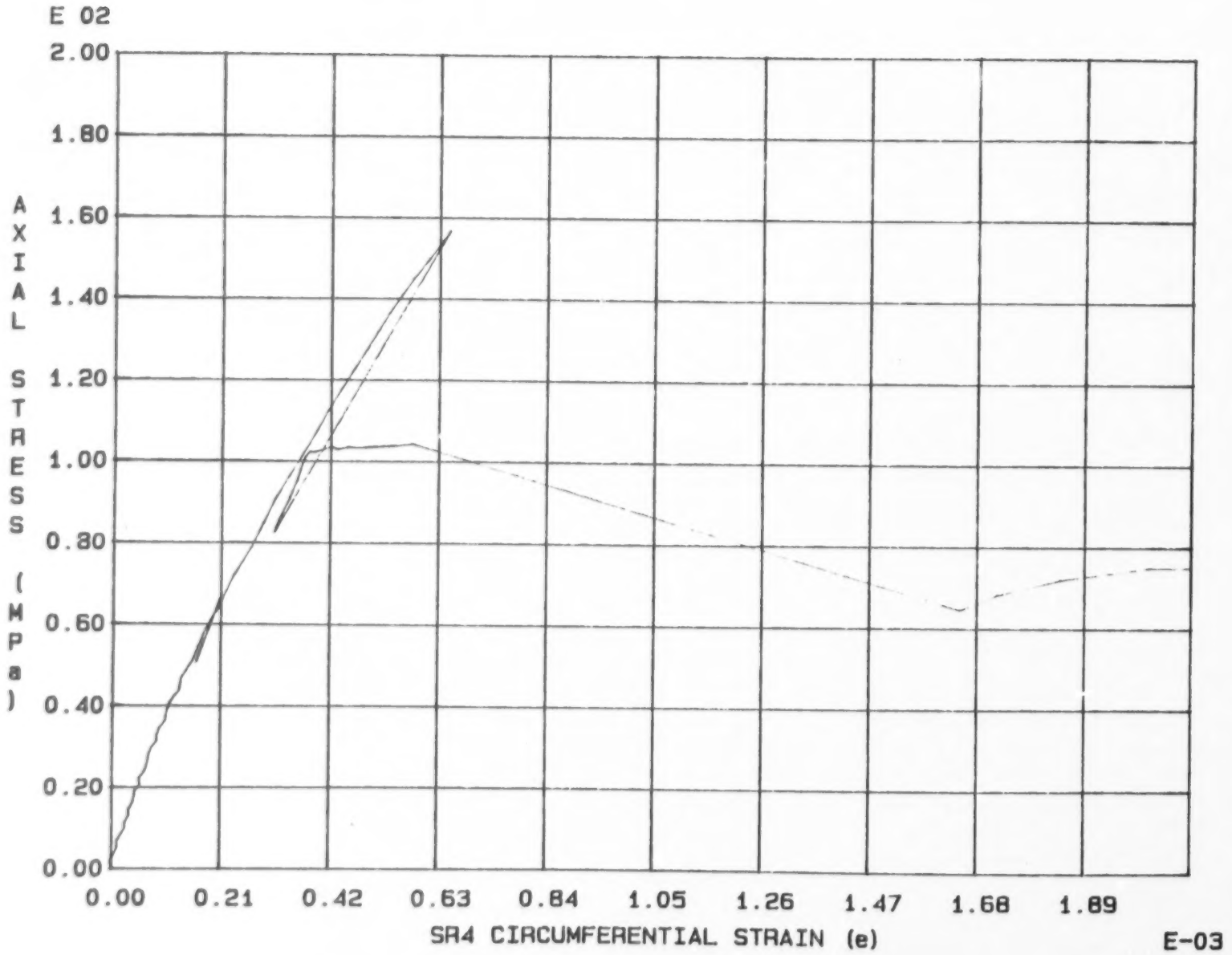


Fig. D-53 E103U

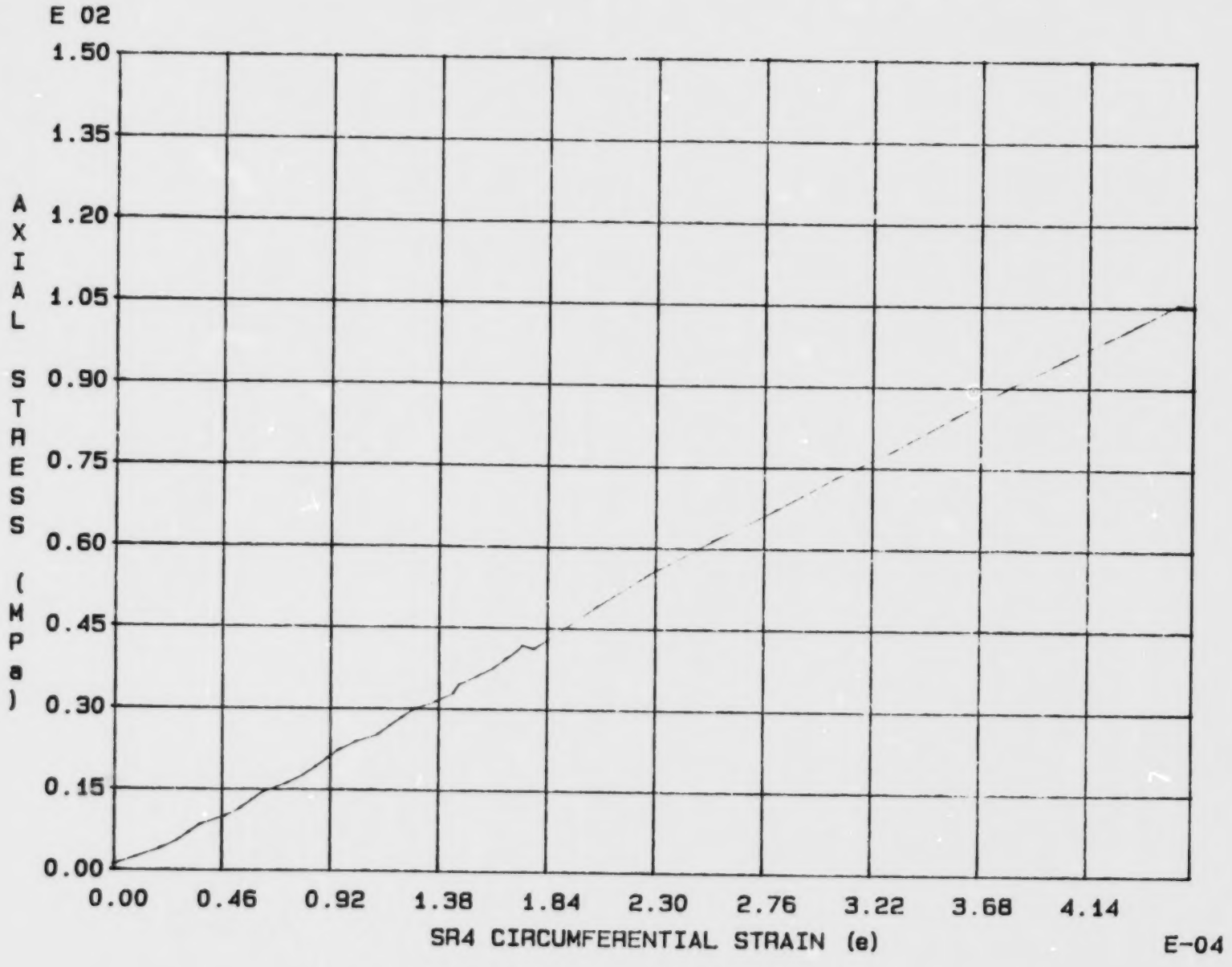


Fig. D-54 E104U

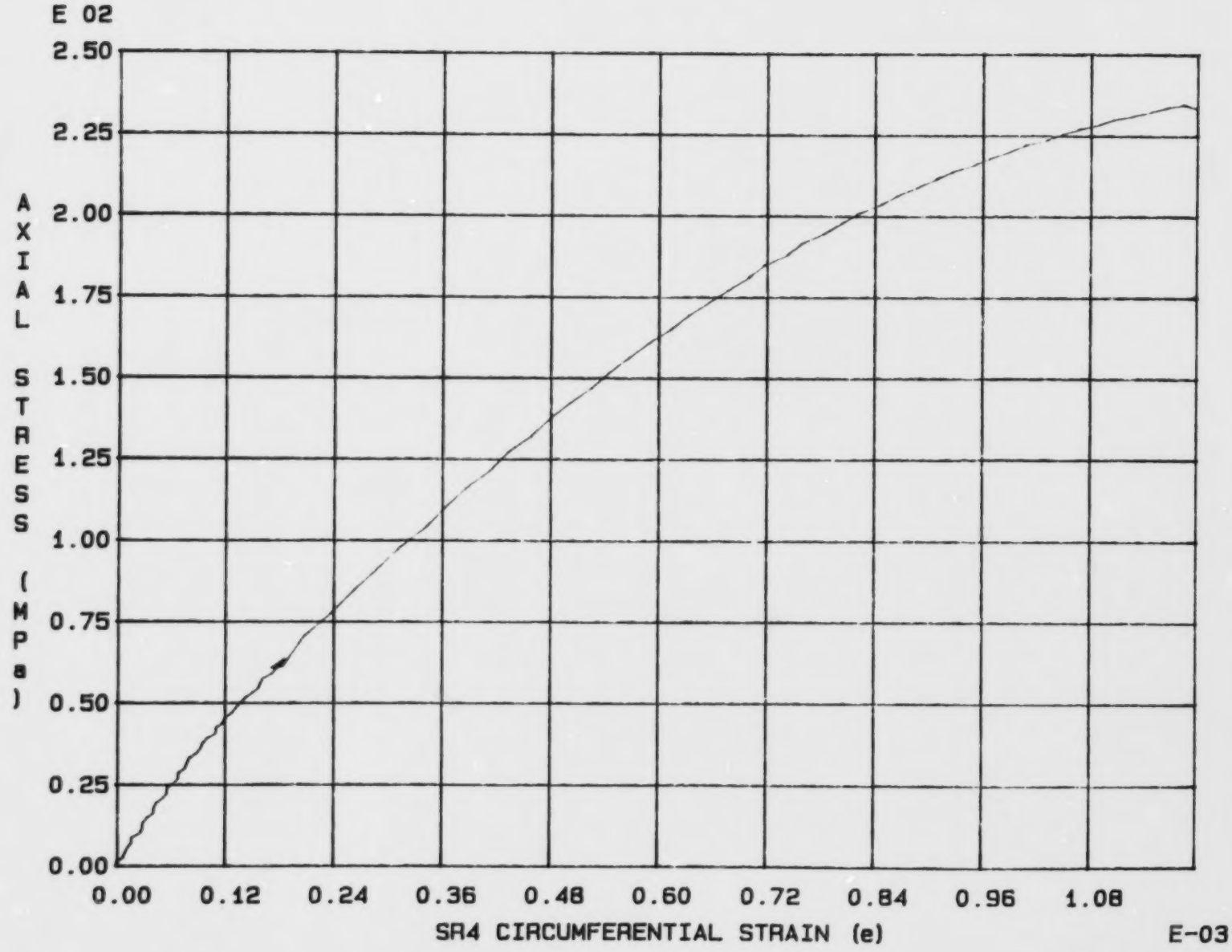


Fig. D-55 E105U

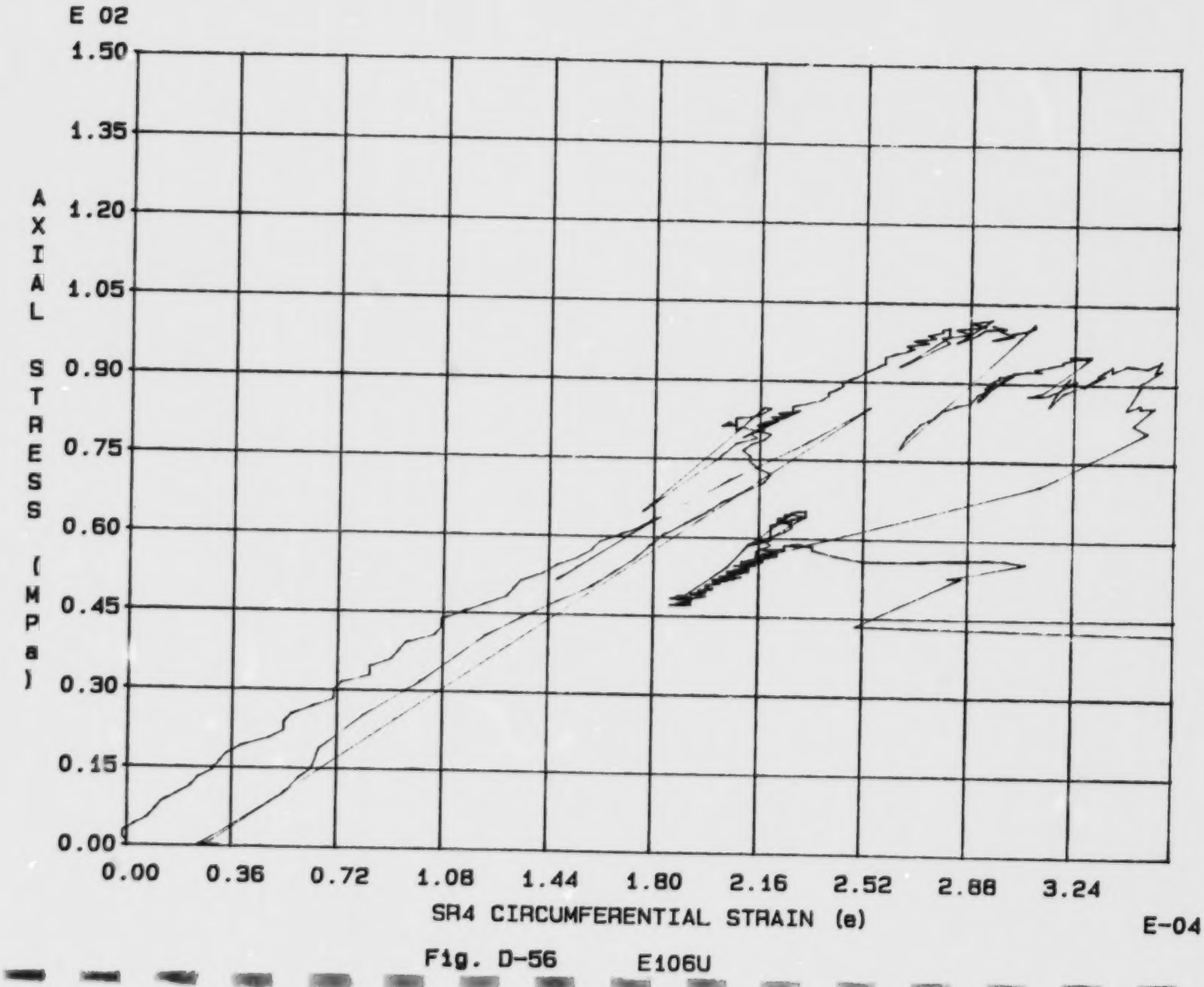


Fig. D-56 E106U

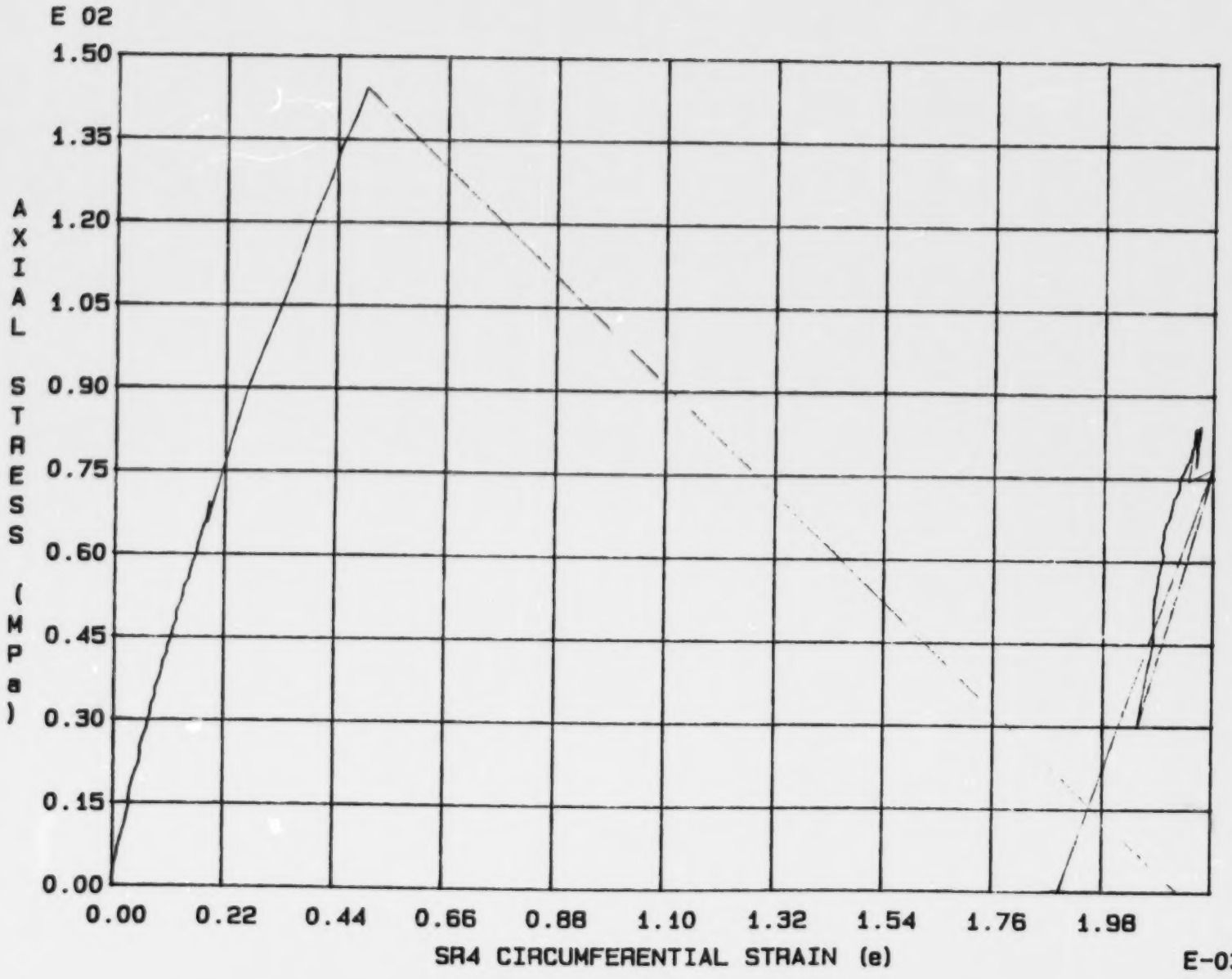


Fig. D-57 E107U

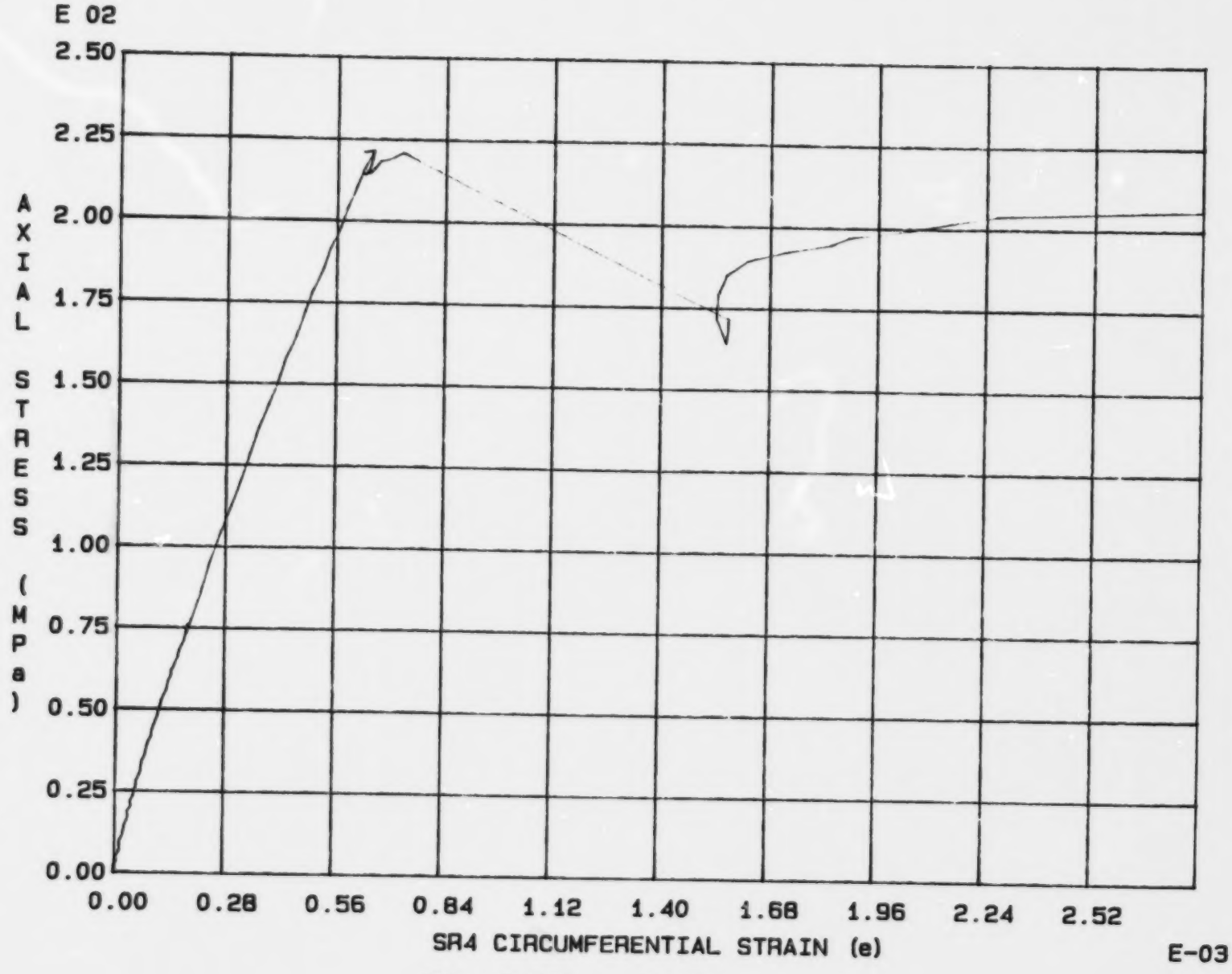


Fig. D-58 E108U

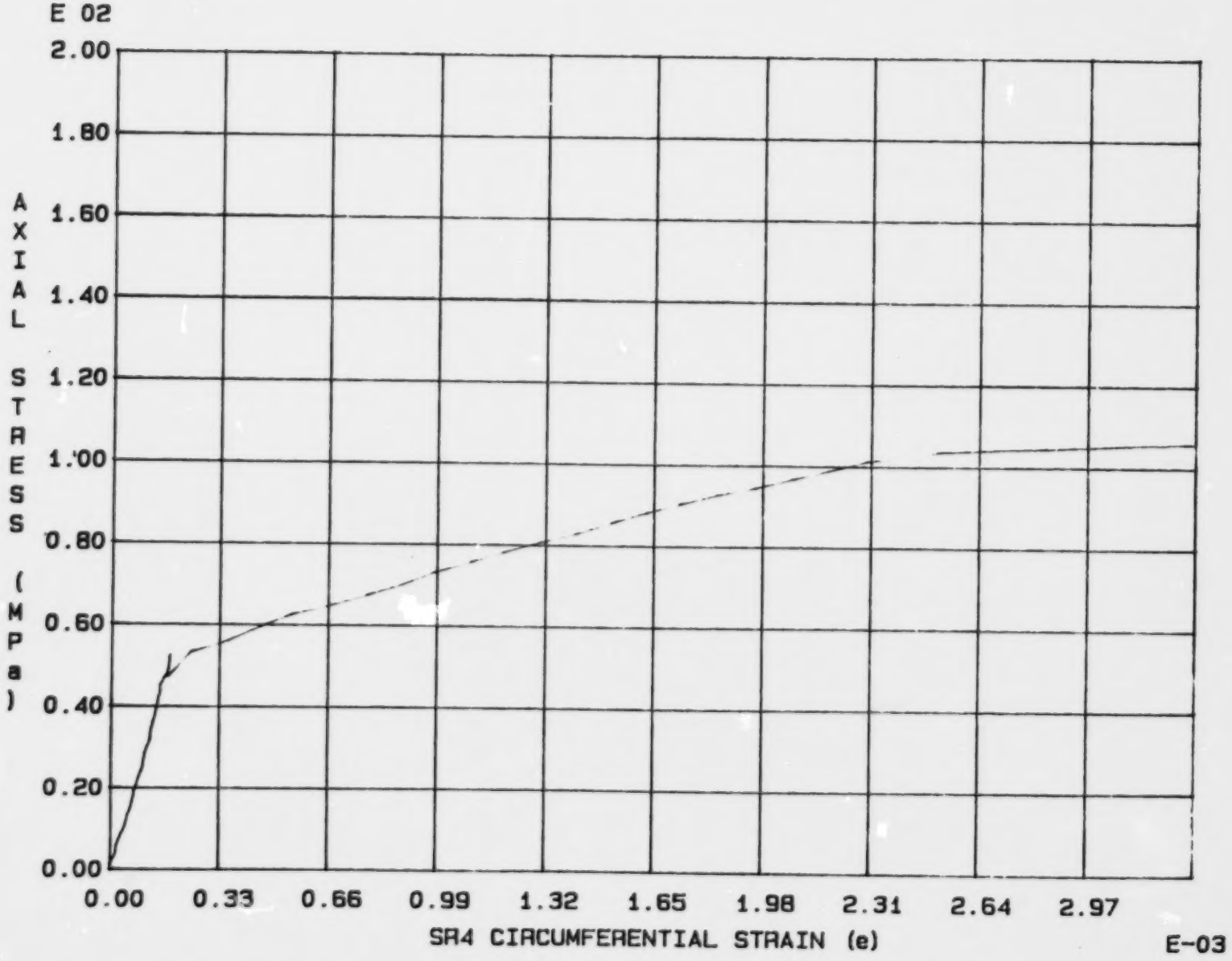


Fig. D-59 E109U

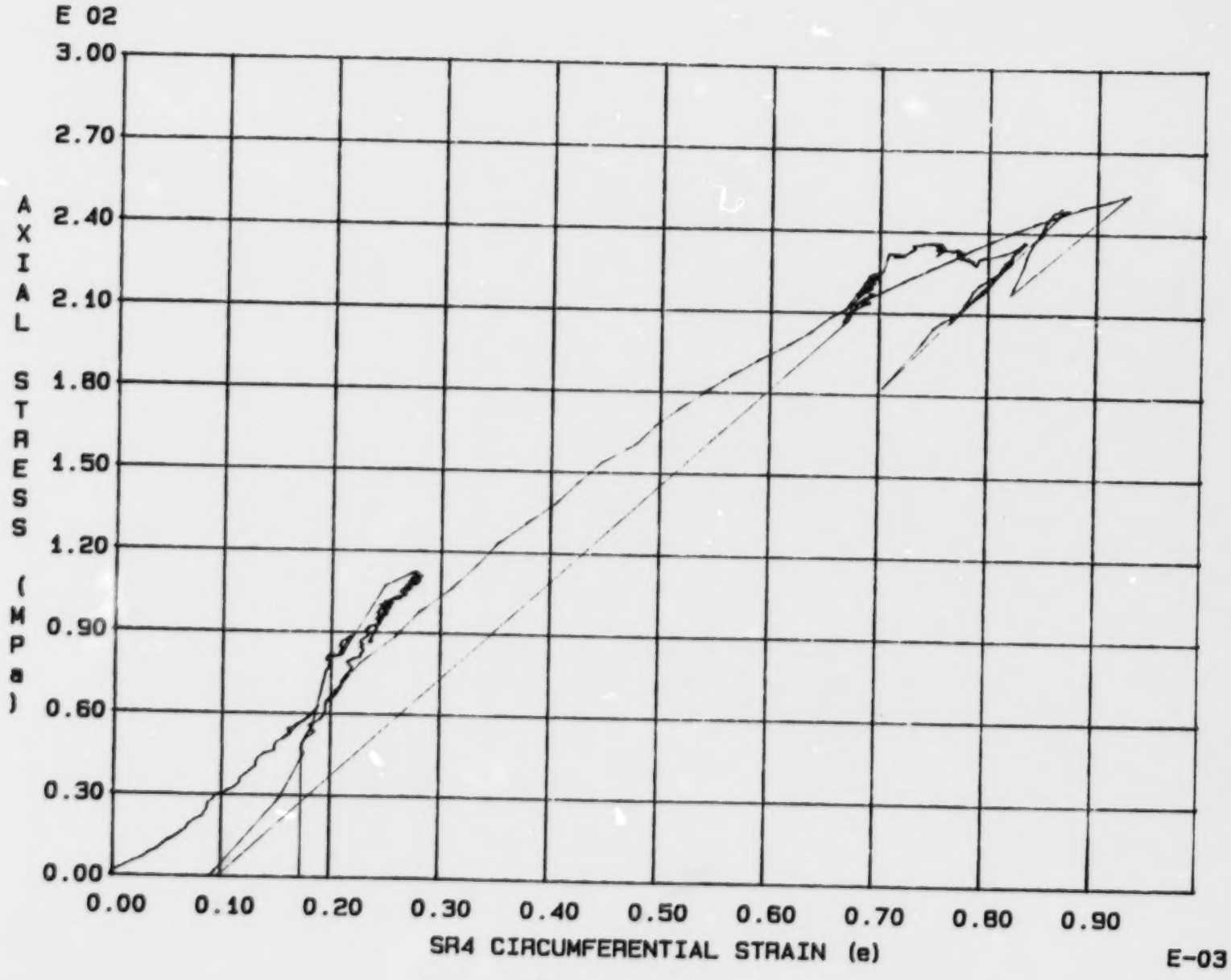


Fig. D-60 E110U

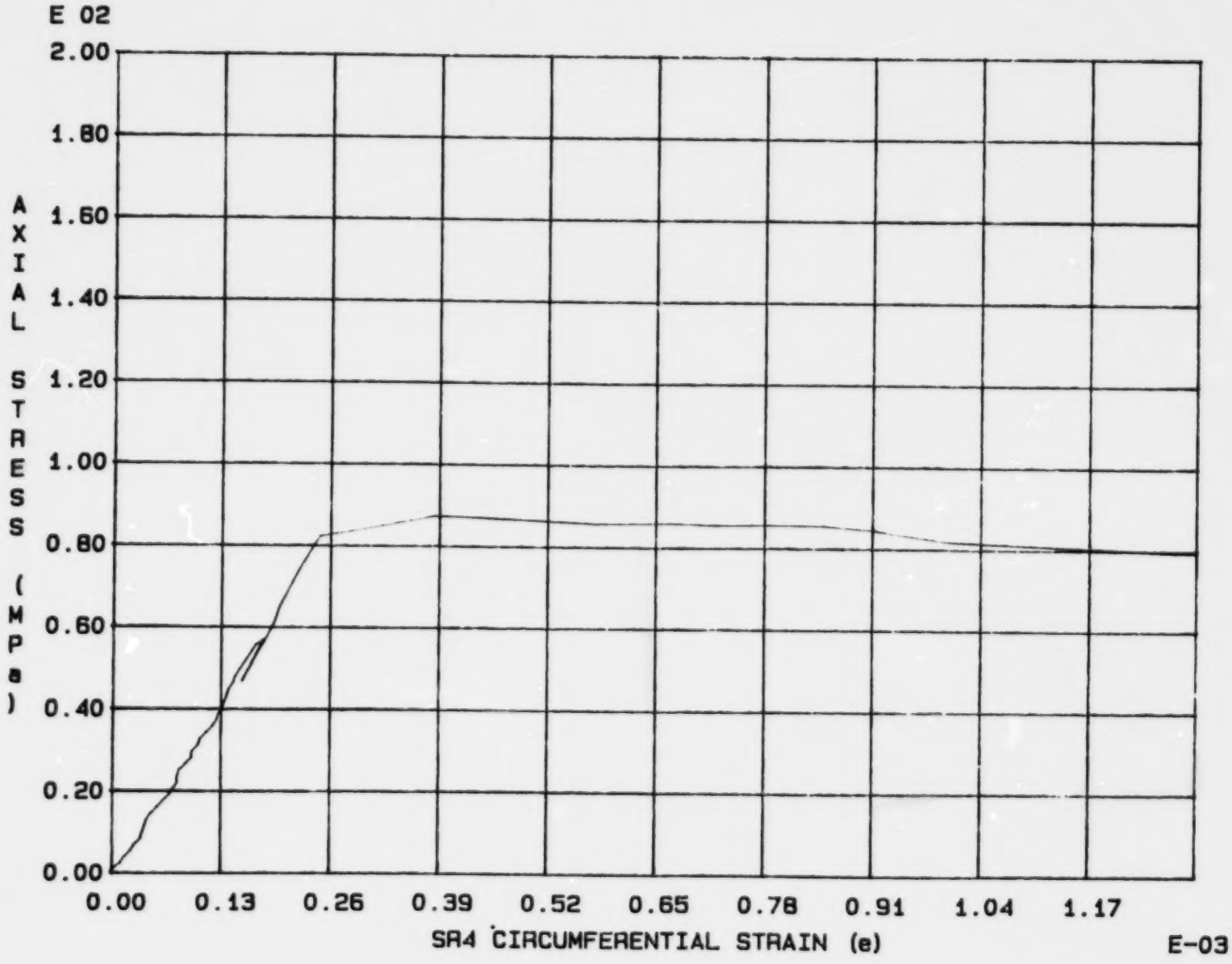


Fig. D-61 E111U

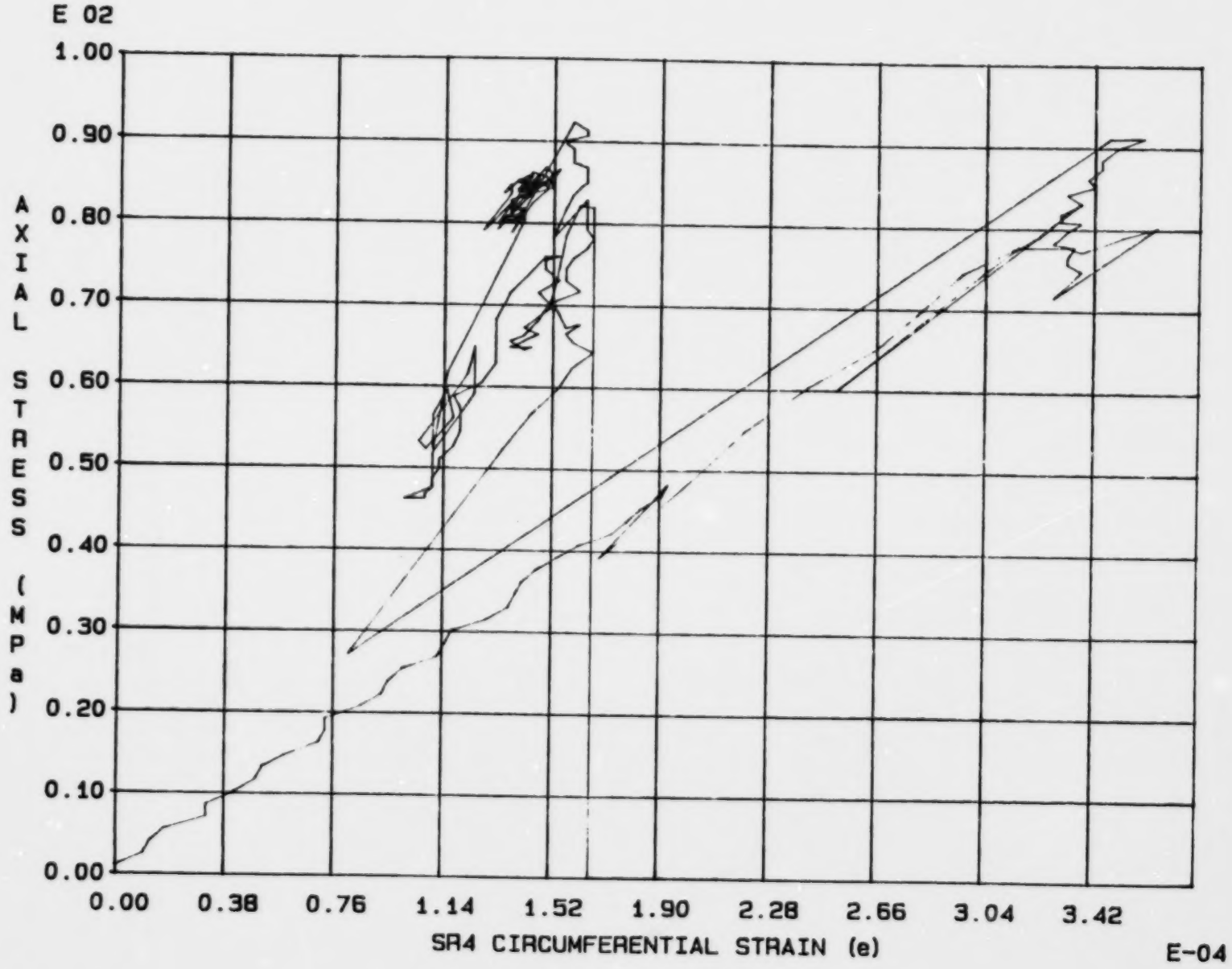


Fig. D-62 E112U

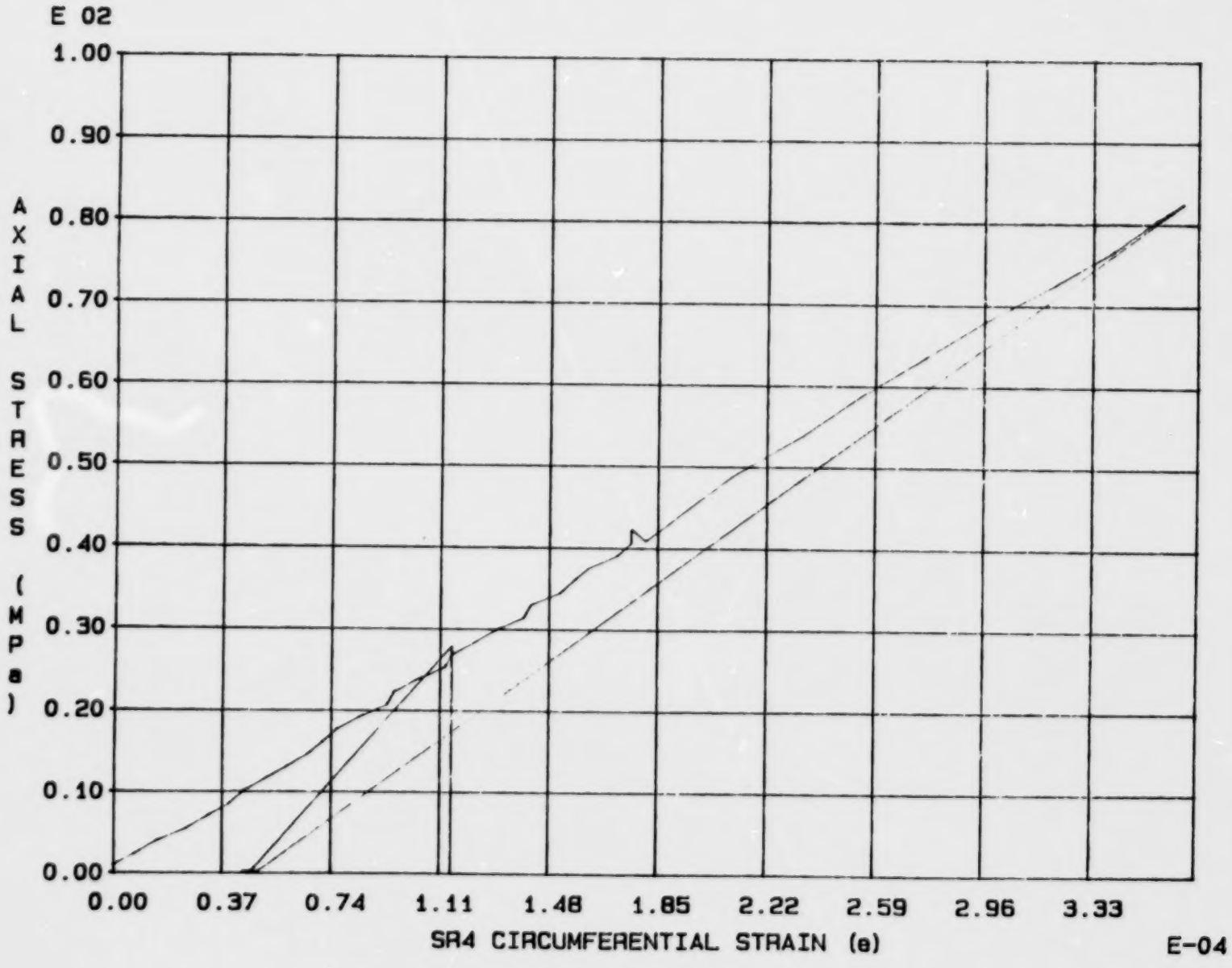


Fig. D-63 E113U

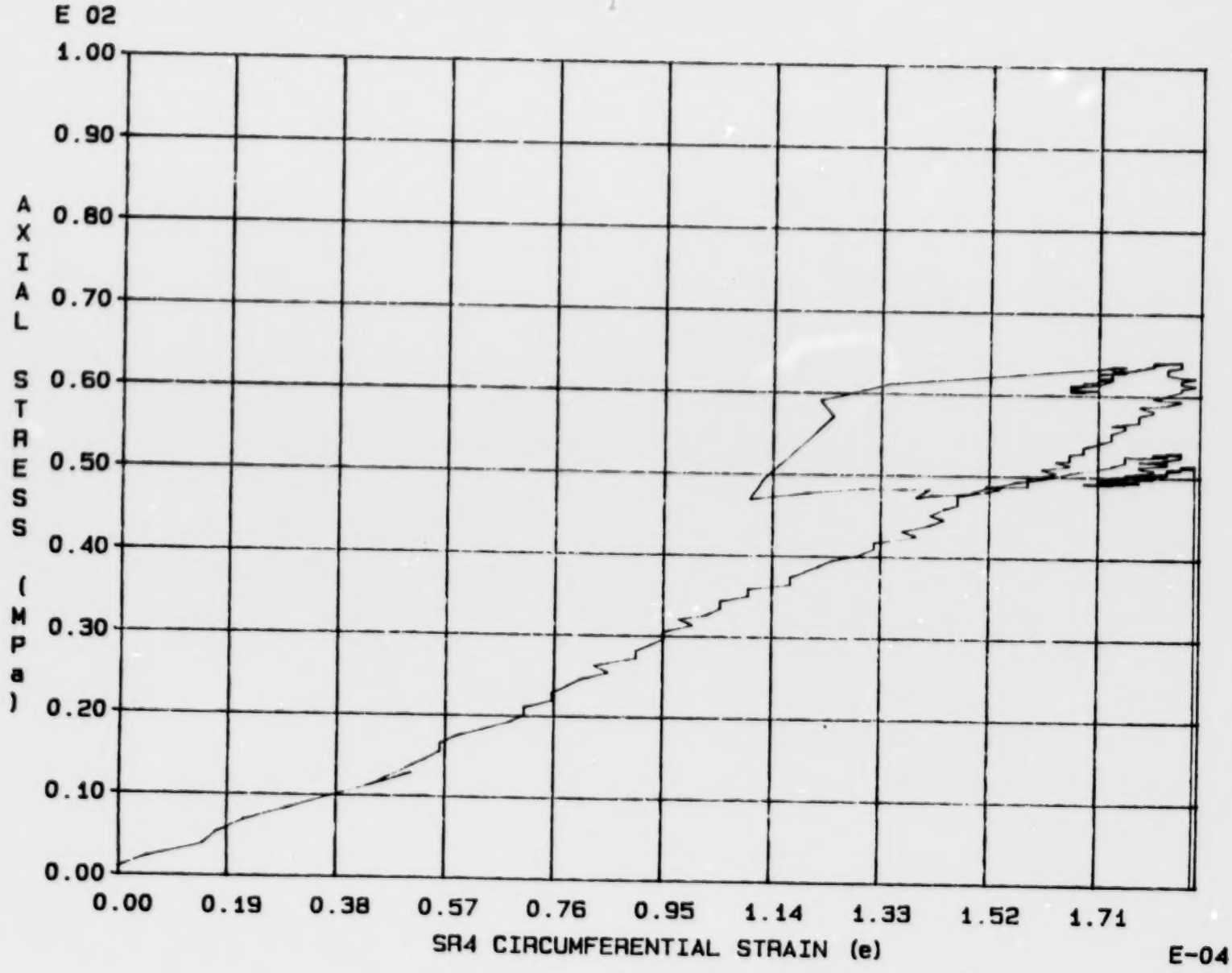


Fig. D-64 E114U

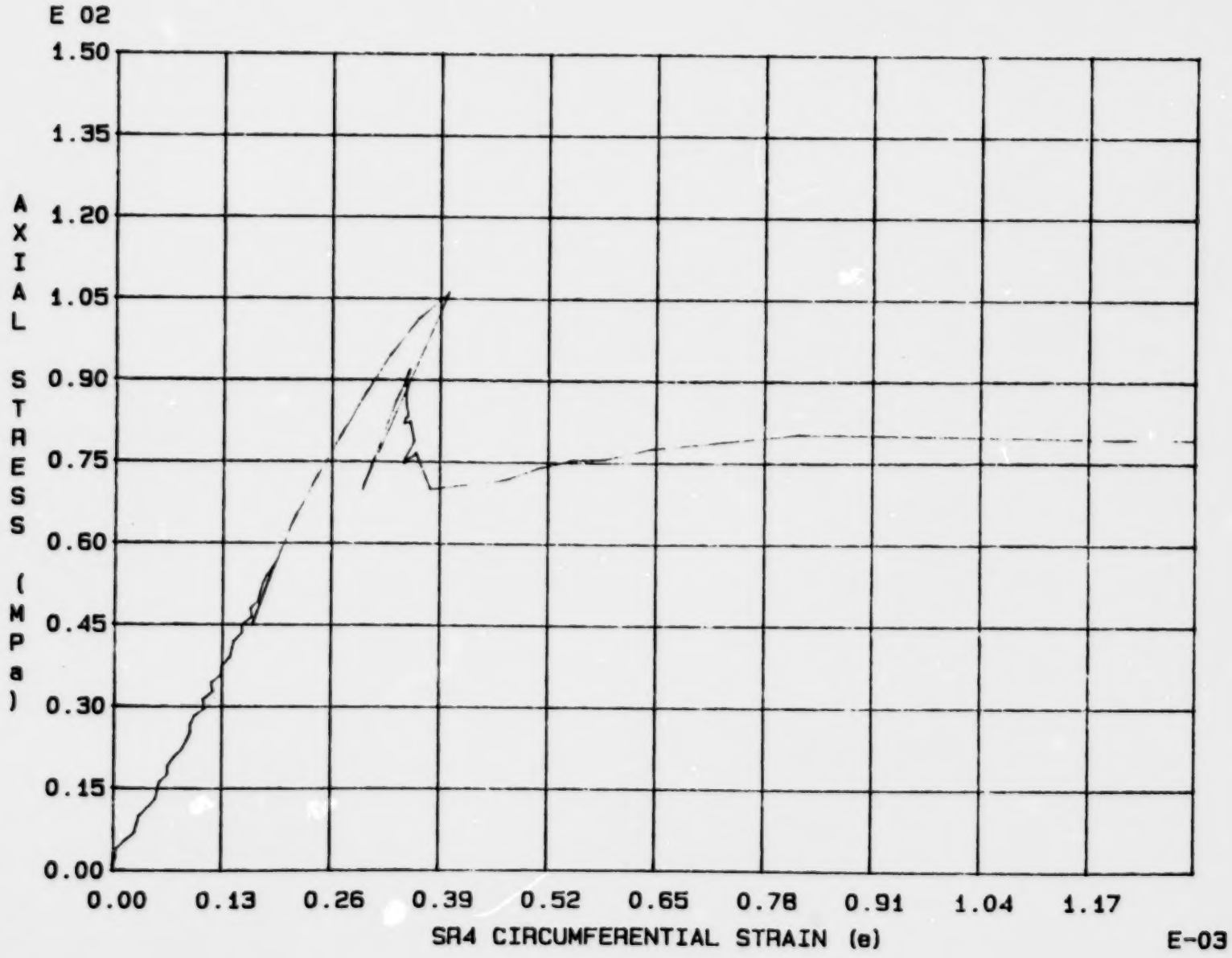


Fig. D-65 E115U

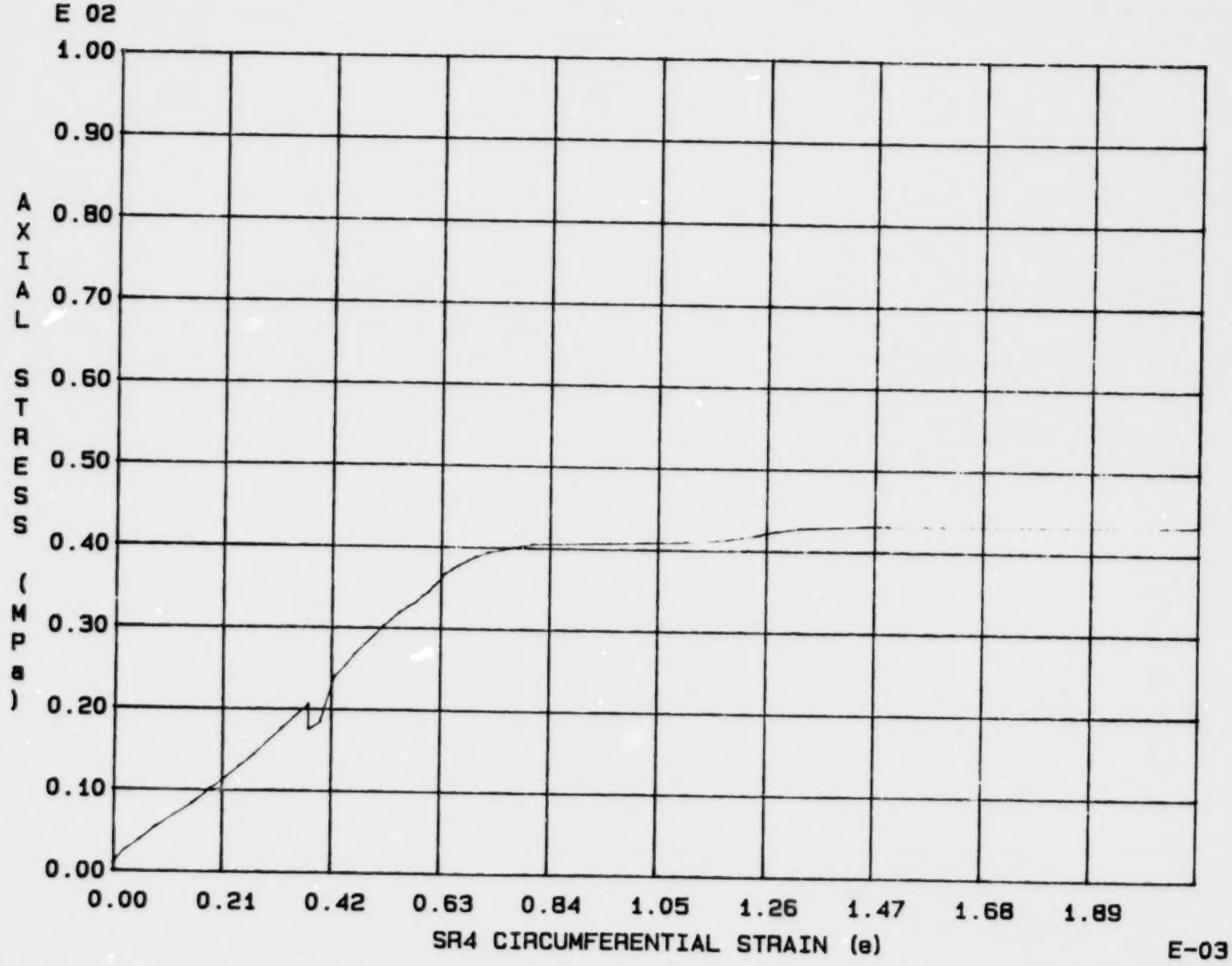


Fig. D-66 E116U

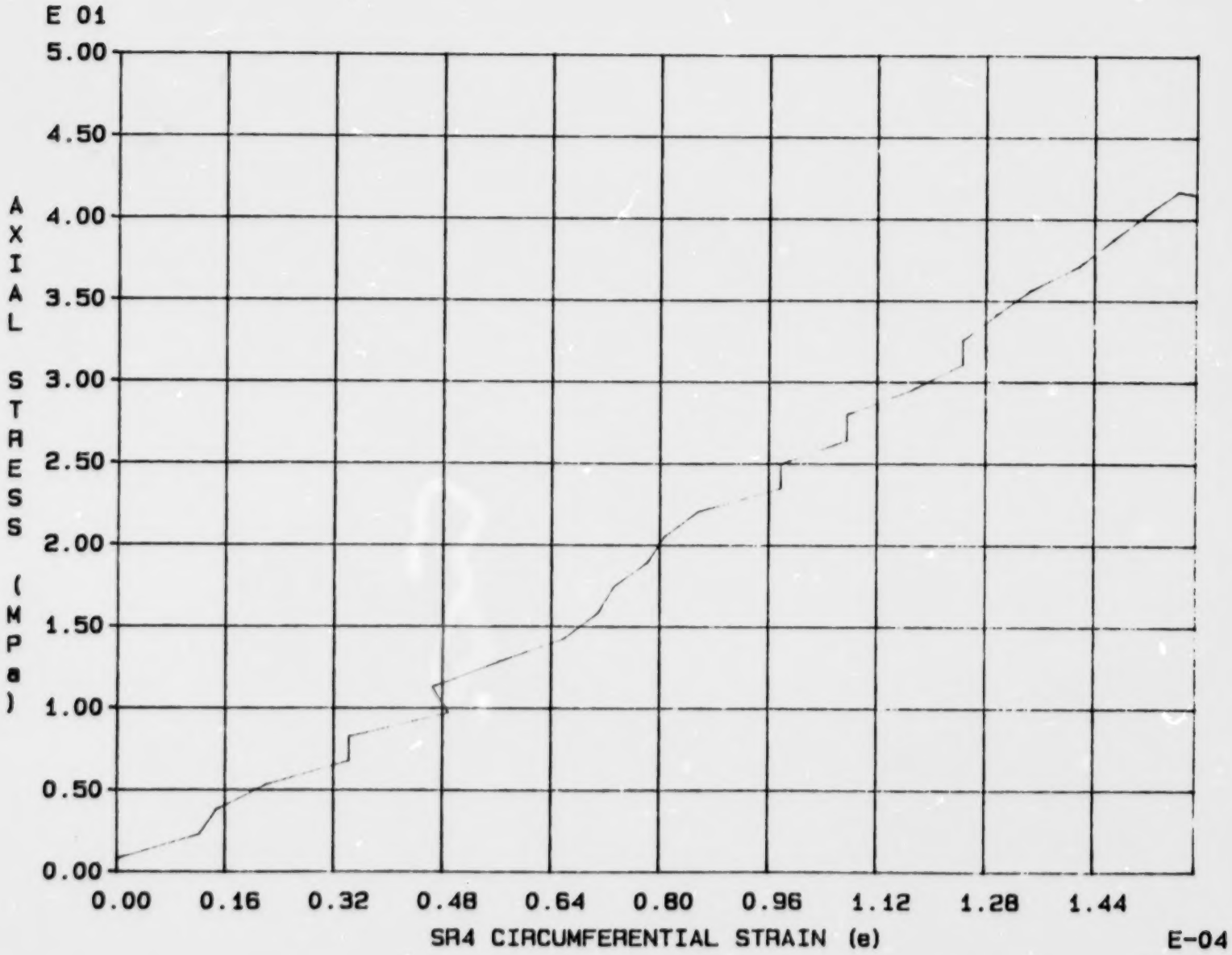


Fig. D-67 E117U

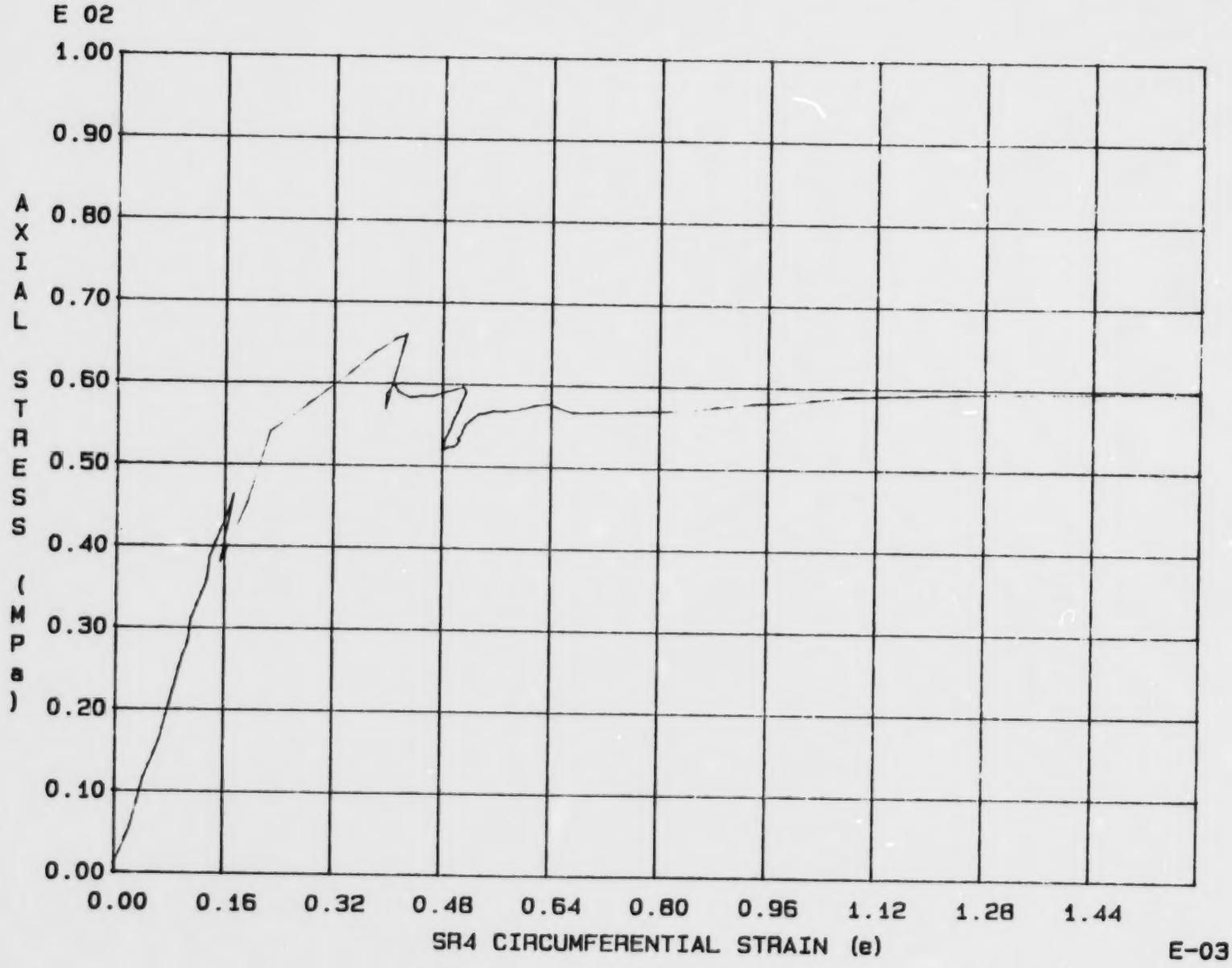


Fig. D-68 E118U

APPENDIX E

STRESS-STRAIN CURVES OF TRIAXIAL TESTS USING AXIAL LVDTs

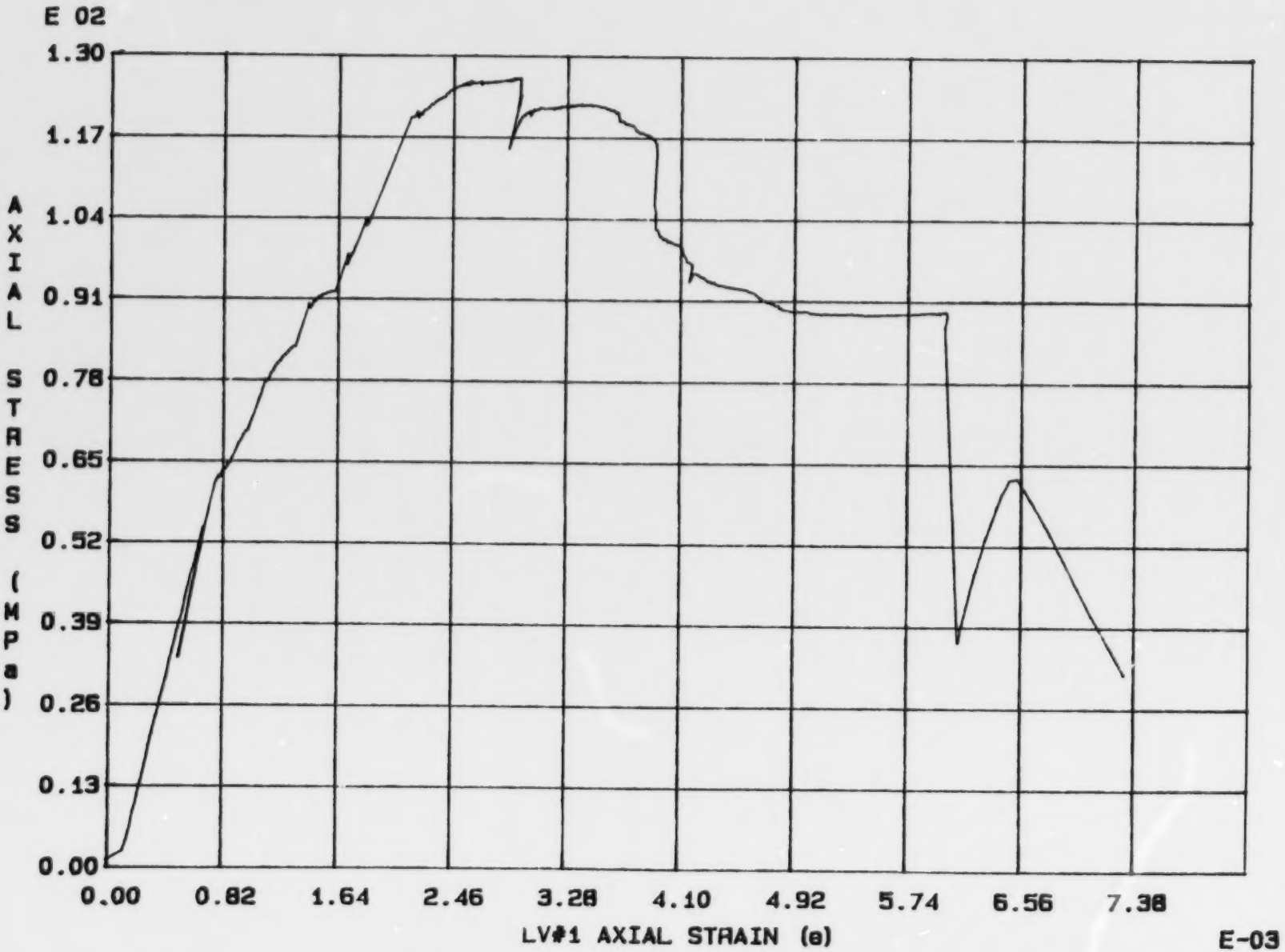

E 02
1.30
1.17
1.04
0.91
0.78
0.65
0.52
0.39
0.26
0.13
0.00
AXIAL STRESS (MPa)
0.00
0.82
1.64
2.46
3.28
4.10
4.92
5.74
6.56
7.38
LV#1 AXIAL STRAIN (e)
E-03

Fig. E-1 E2T

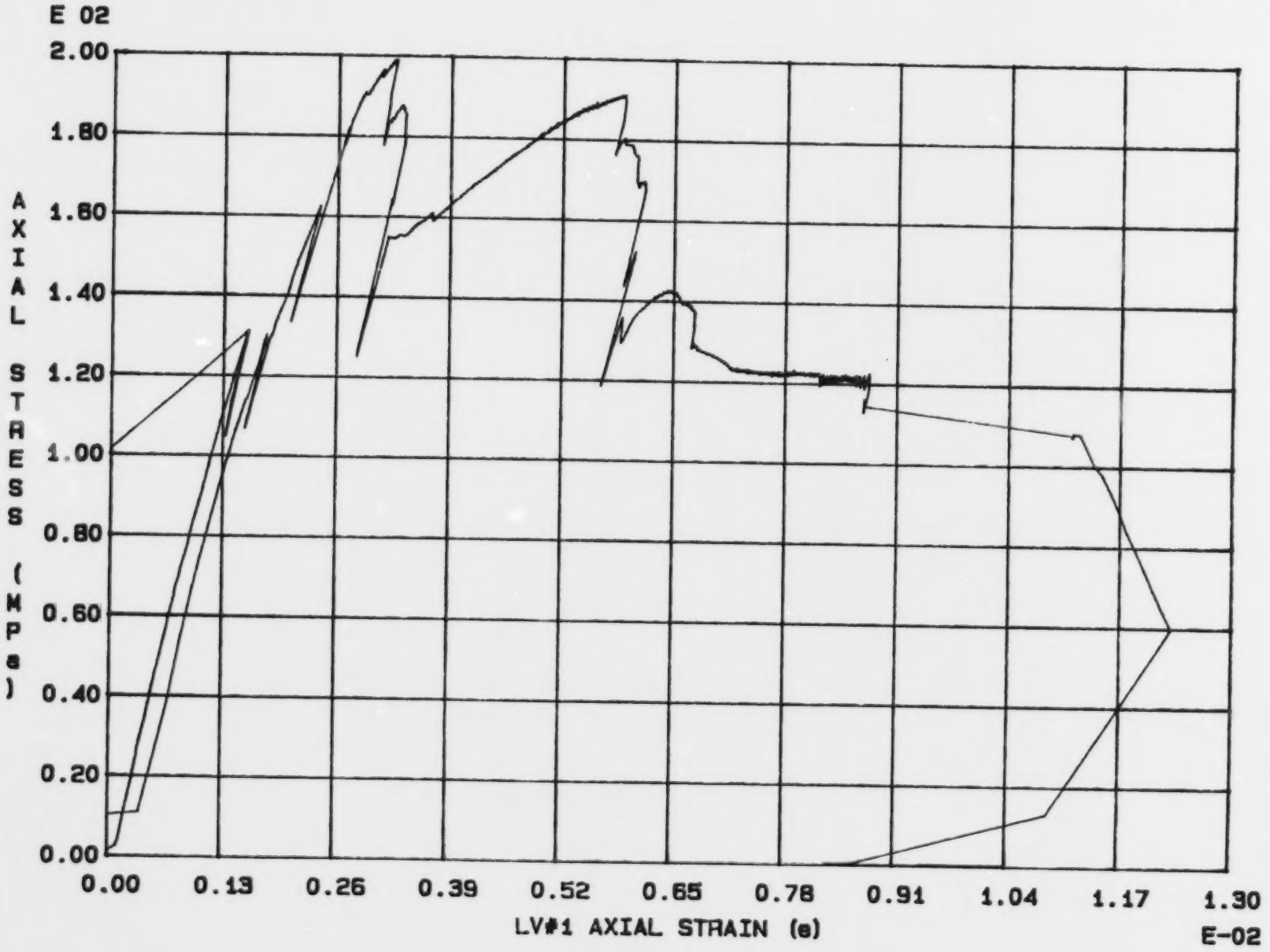

E 02
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
AXIAL STRESS (MPa)
0.00
0.13
0.26
0.39
0.52
0.65
0.78
0.91
1.04
1.17
1.30
LV#1 AXIAL STRAIN (e)
E-02

Fig. E-2 E4T

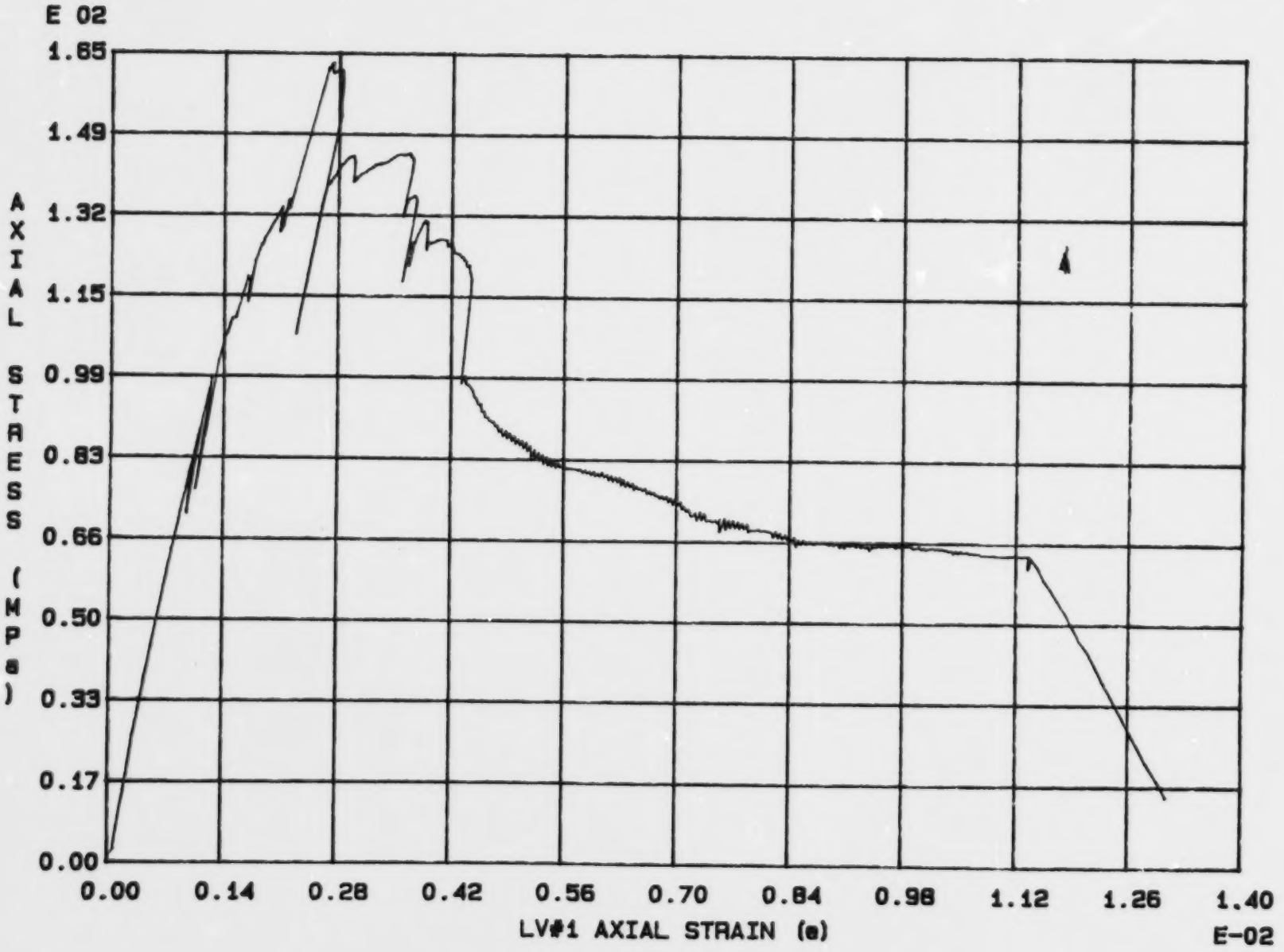

E 02
1.65
1.49
1.32
1.15
0.99
0.83
0.66
0.50
0.33
0.17
0.00
AXIAL STRESS (MPa)
0.00
0.14
0.28
0.42
0.56
0.70
0.84
0.98
1.12
1.26
1.40
LV#1 AXIAL STRAIN (e)
E-02

Fig. E-3 E6T

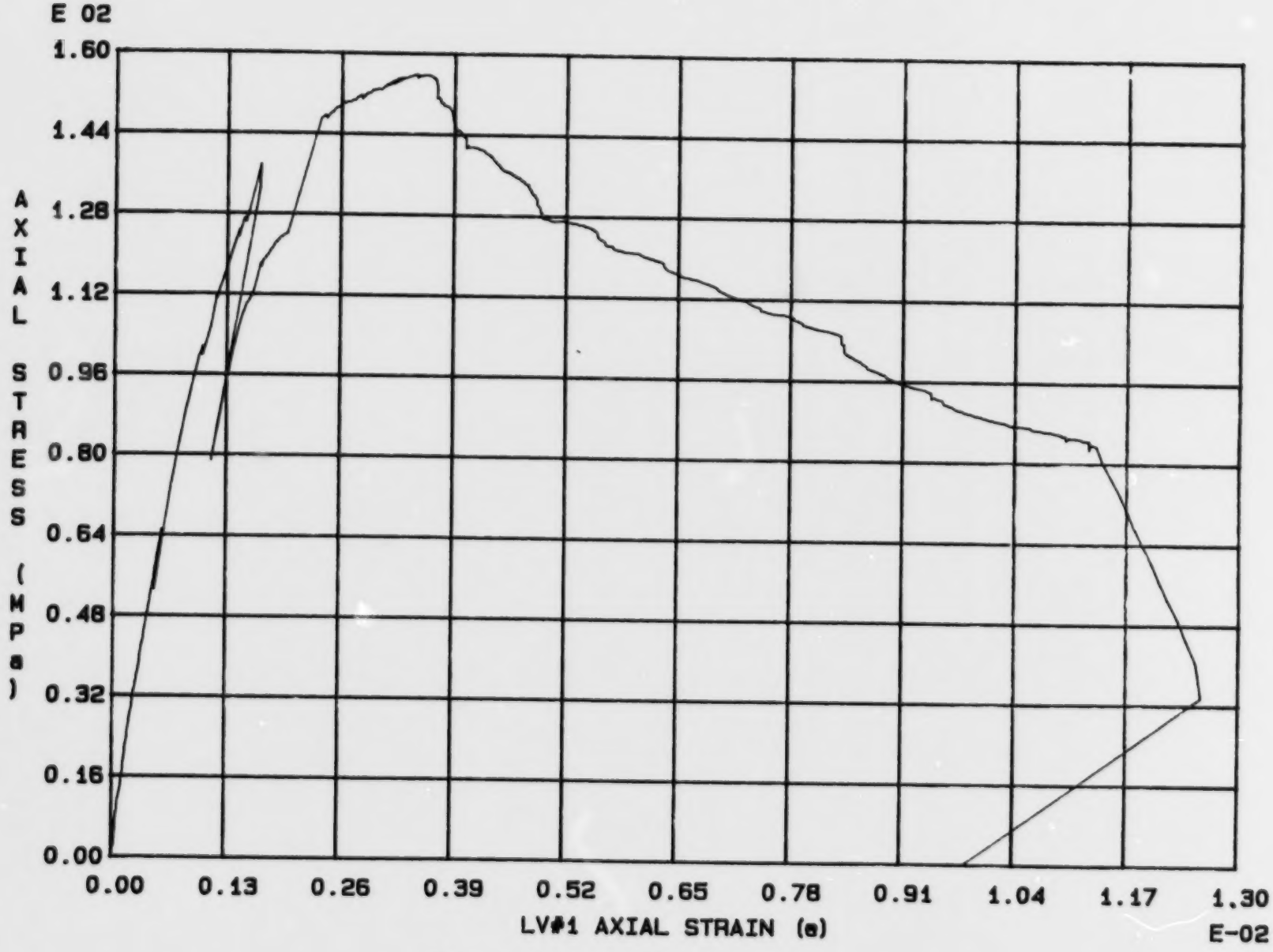

E 02
1.60
1.44
1.28
1.12
0.96
0.80
0.64
0.48
0.32
0.16
0.00
AXIAL STRESS (MPa)
0.00
0.13
0.26
0.39
0.52
0.65
0.78
0.91
1.04
1.17
1.30
LV#1 AXIAL STRAIN (e)
E-02

Fig. E-4 E8T

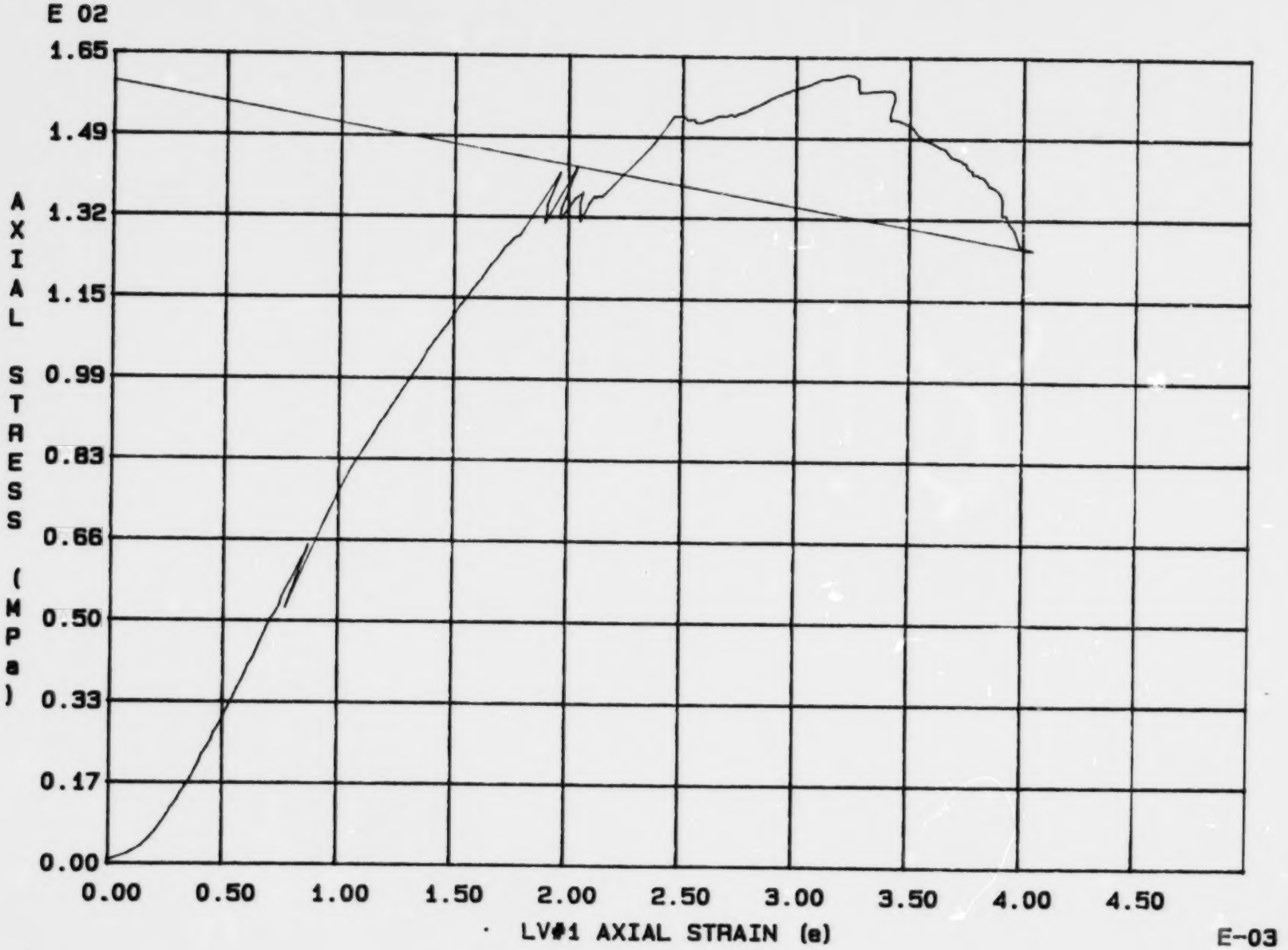

E 02
1.65
1.49
1.32
1.15
0.99
0.83
0.66
0.50
0.33
0.17
0.00
AXIAL STRESS (MPa)
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
LV#1 AXIAL STRAIN (e)
E-03

Fig. E-5 E10T

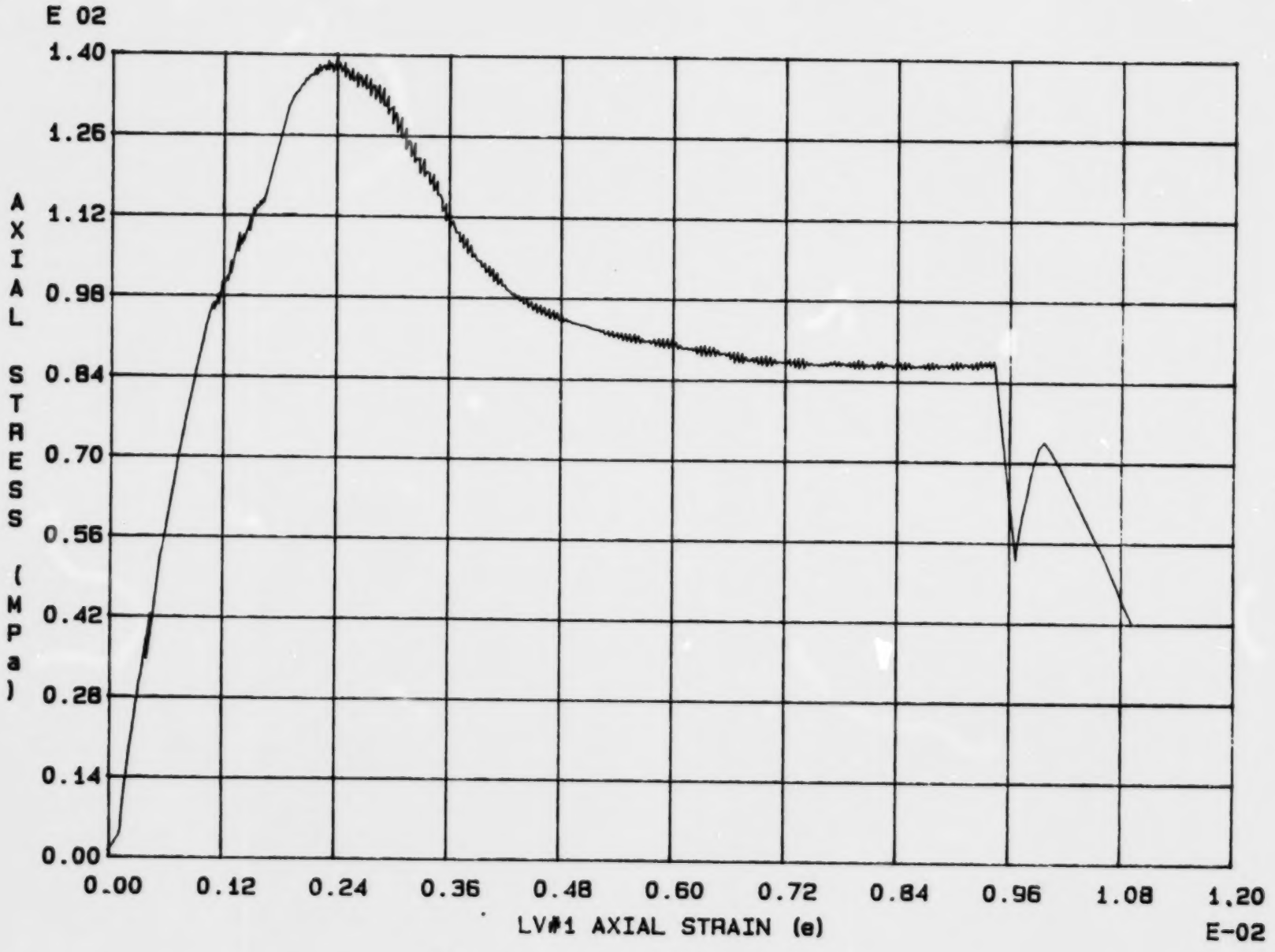

E 02
1.40
1.26
1.12
0.98
0.84
0.70
0.56
0.42
0.28
0.14
0.00
AXIAL STRESS (MPa)
0.00
0.12
0.24
0.36
0.48
0.60
0.72
0.84
0.96
1.08
1.20
LV#1 AXIAL STRAIN (e)
E-02

Fig. E-6 E12T

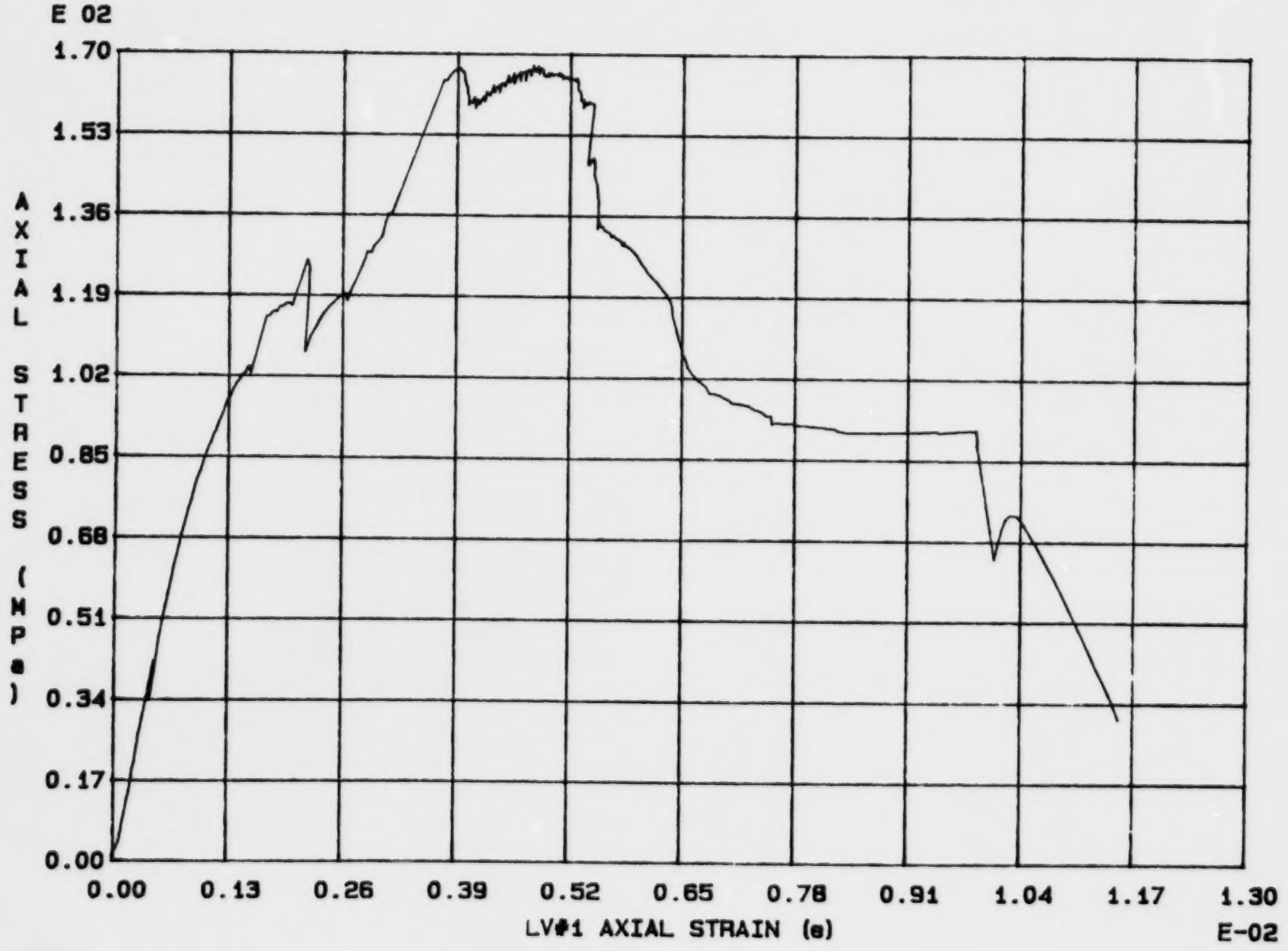

E 02
1.70
1.53
1.36
1.19
1.02
0.85
0.68
0.51
0.34
0.17
0.00
AXIAL STRESS (MPa)
0.00
0.13
0.26
0.39
0.52
0.65
0.78
0.91
1.04
1.17
1.30
LV#1 AXIAL STRAIN (e)
E-02

Fig. E-7 E14T

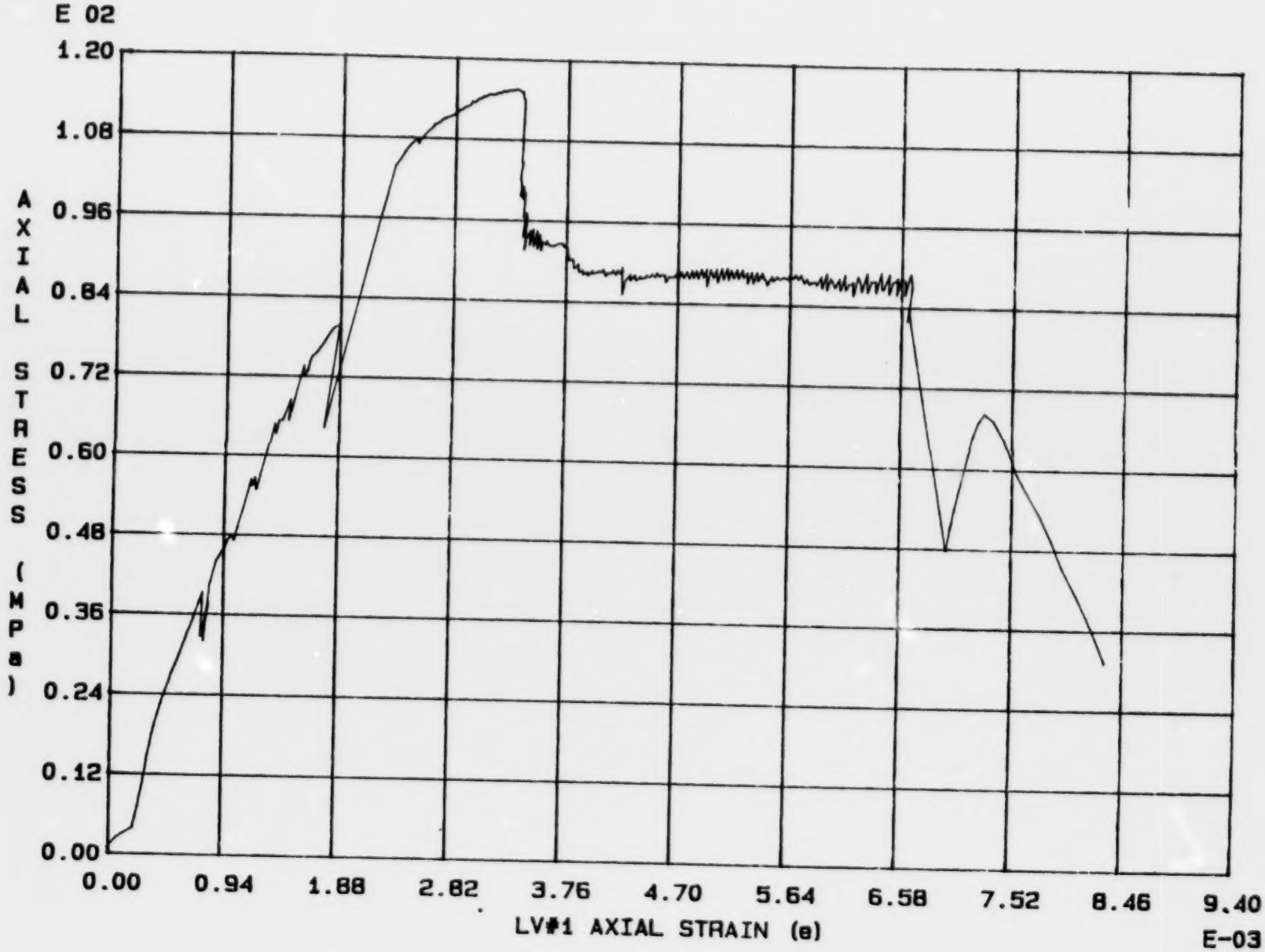

E 02
1.20
1.08
0.96
0.84
0.72
0.60
0.48
0.36
0.24
0.12
0.00
AXIAL STRESS (MPa)
0.00
0.94
1.88
2.82
3.76
4.70
5.64
6.58
7.52
8.46
9.40
LV#1 AXIAL STRAIN (e)
E-03

Fig. E-8 E16T

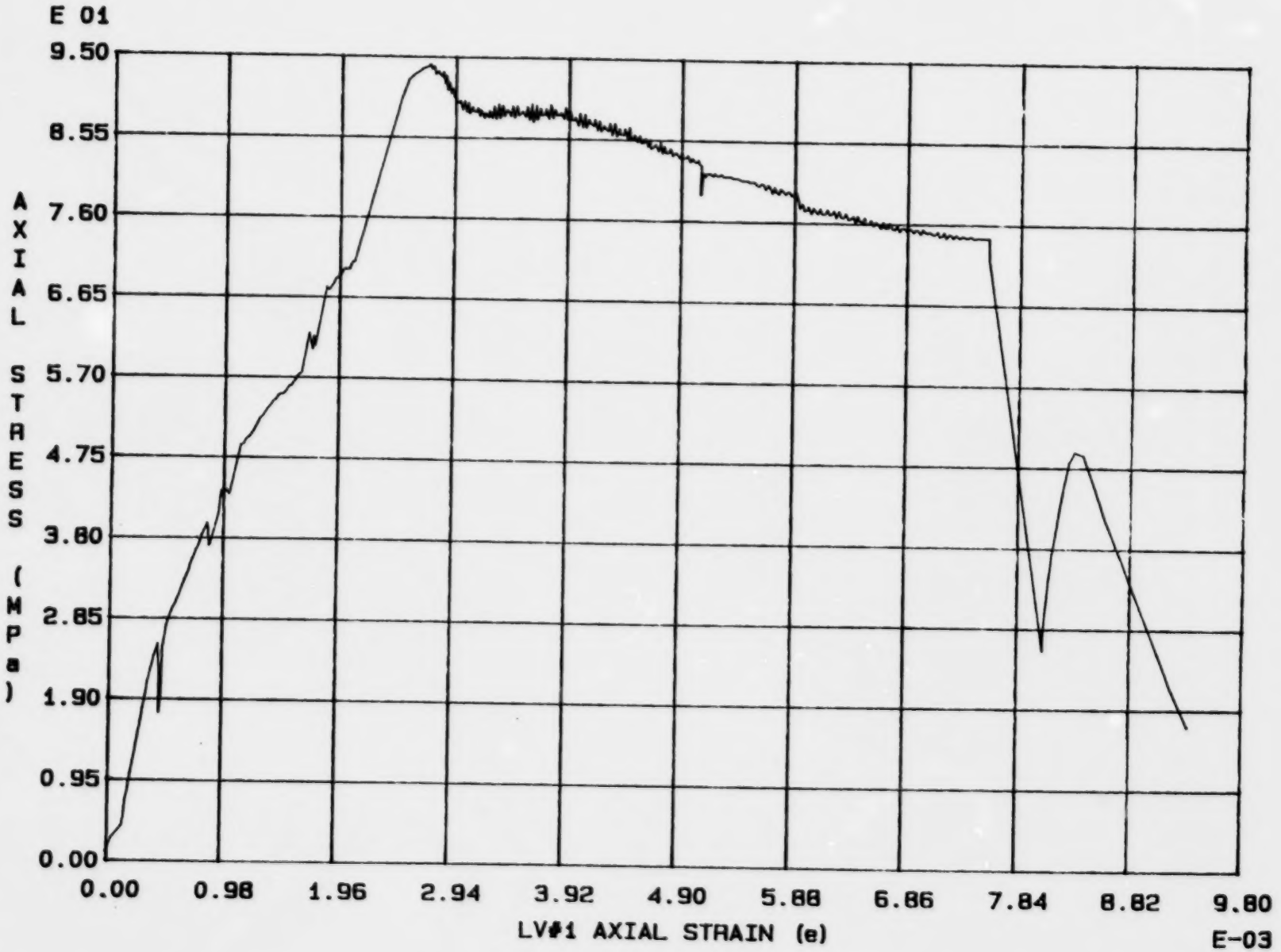

E 01
9.50
8.55
7.60
6.65
5.70
4.75
3.80
2.85
1.90
0.95
0.00
AXIAL STRESS (MPa)
0.00
0.98
1.96
2.94
3.92
4.90
5.88
6.86
7.84
8.82
9.80
LV#1 AXIAL STRAIN (e)
E-03

Fig. E-9 E18T

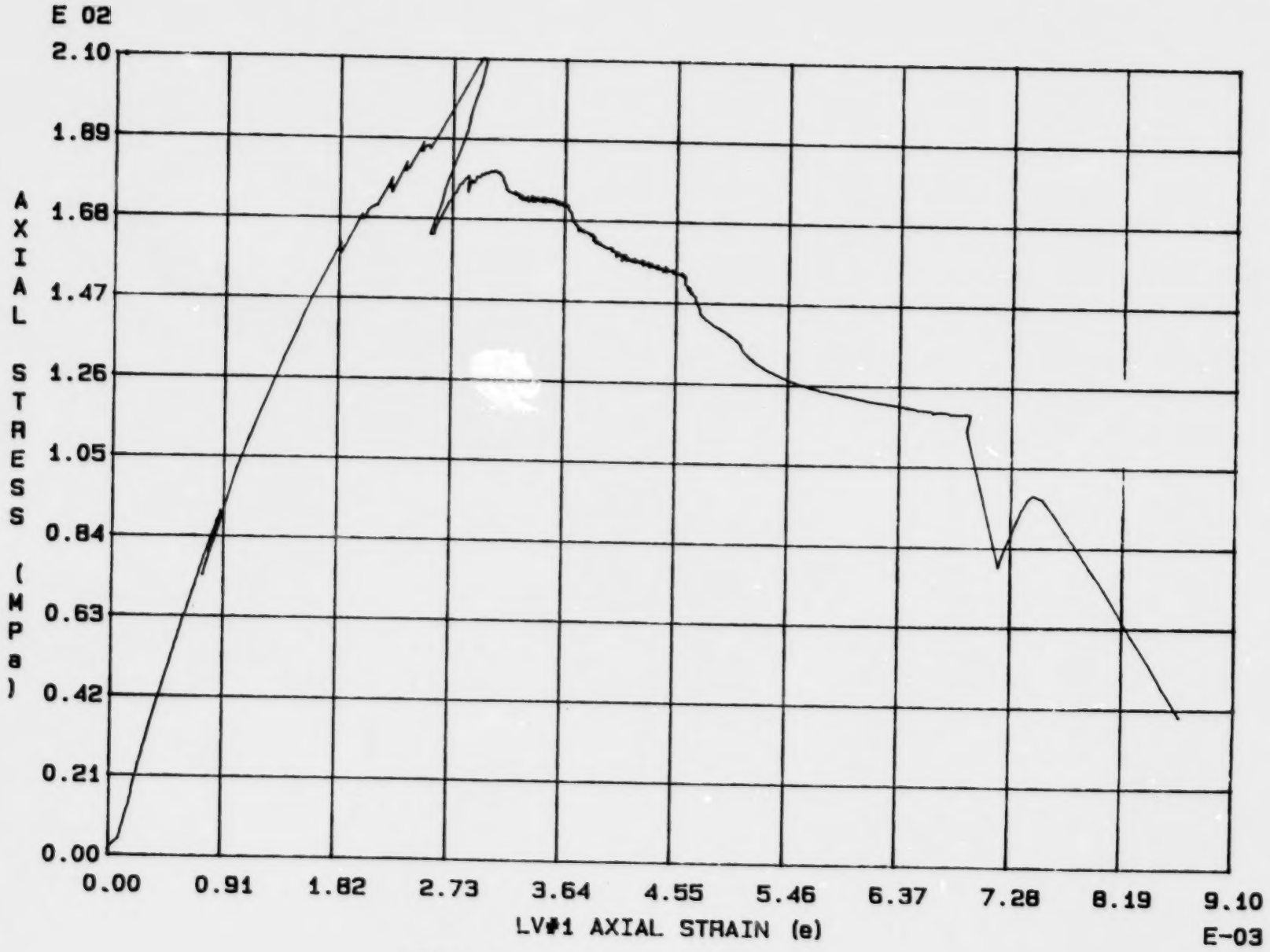

E 02
2.10
1.89
1.68
1.47
1.26
1.05
0.84
0.63
0.42
0.21
0.00
AXIAL STRESS (MPa)
0.00
0.91
1.82
2.73
3.64
4.55
5.46
6.37
7.28
8.19
9.10
LV#1 AXIAL STRAIN (e)
E-03

Fig. E-10 E20T

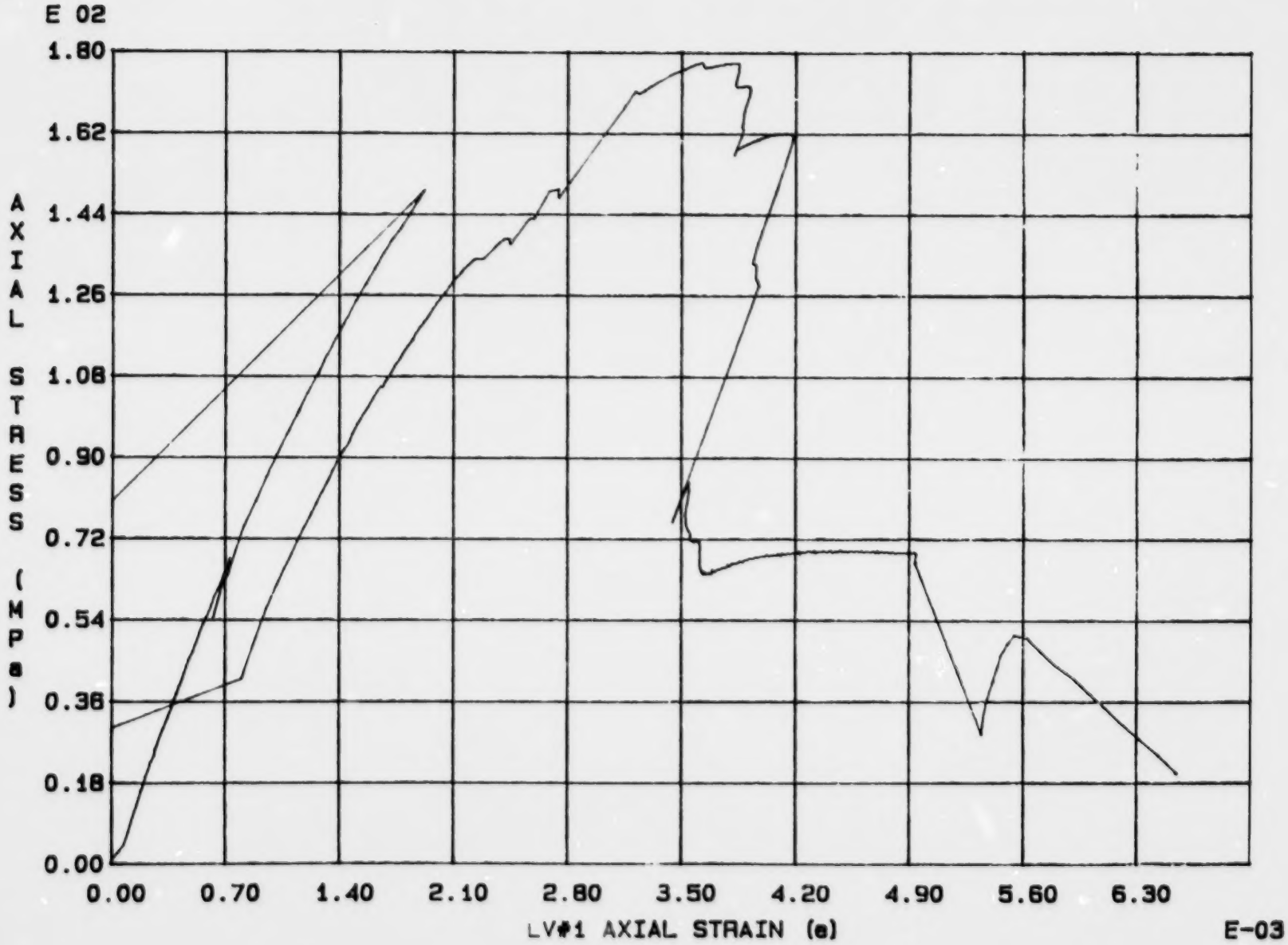

E 02
1.80
1.62
1.44
1.26
1.08
0.90
0.72
0.54
0.36
0.18
0.00
AXIAL STRESS (MPa)
0.00
0.70
1.40
2.10
2.80
3.50
4.20
4.90
5.60
6.30
LV#1 AXIAL STRAIN (e)
E-03

Fig. E-11 E22T

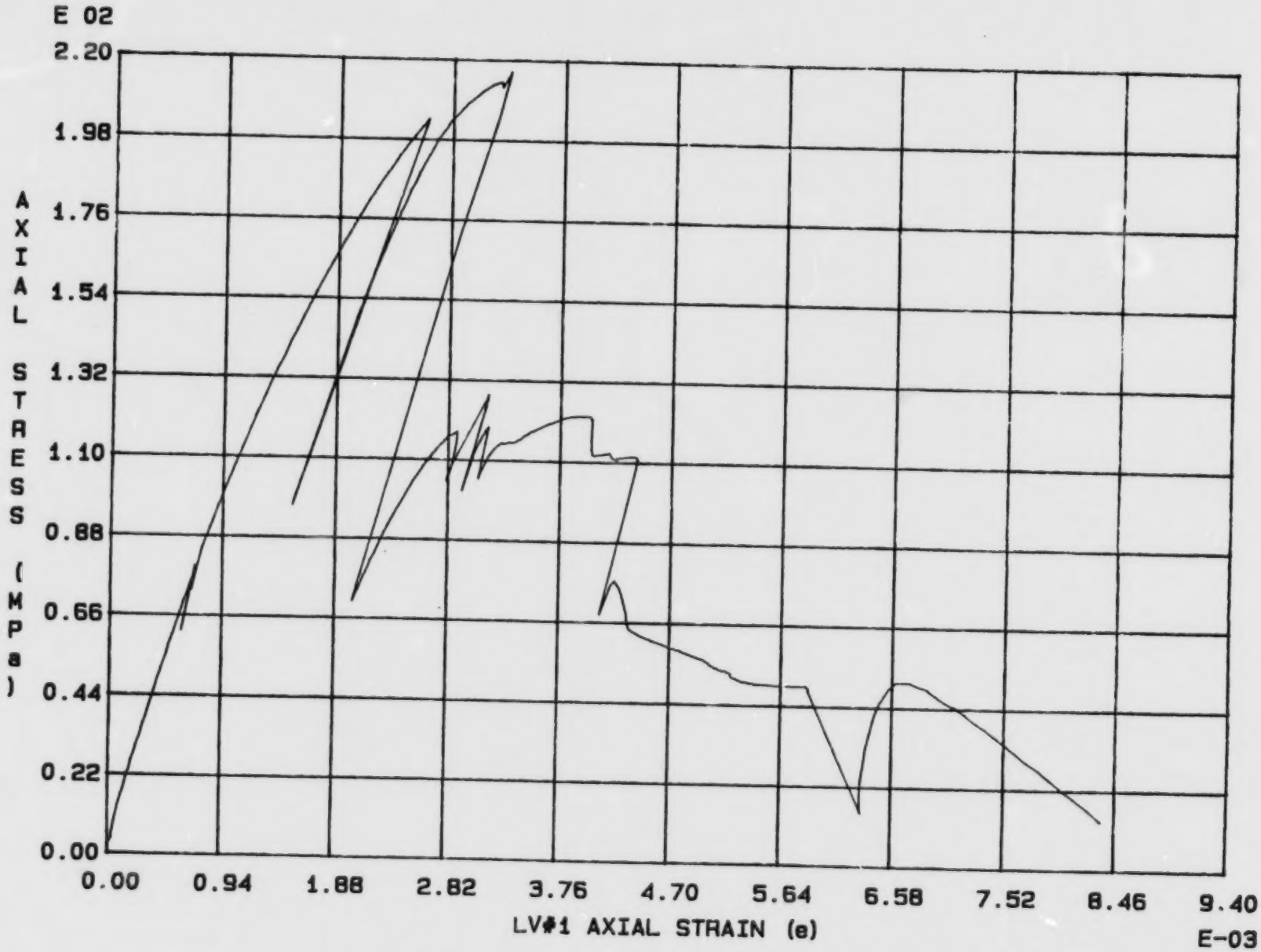

E 02
2.20
1.98
1.76
1.54
1.32
1.10
0.88
0.66
0.44
0.22
0.00
AXIAL STRESS (MPa)
0.00
0.94
1.88
2.82
3.76
4.70
5.64
6.58
7.52
8.46
9.40
E-03
LV#1 AXIAL STRAIN (e)

Fig. E-12 E24T

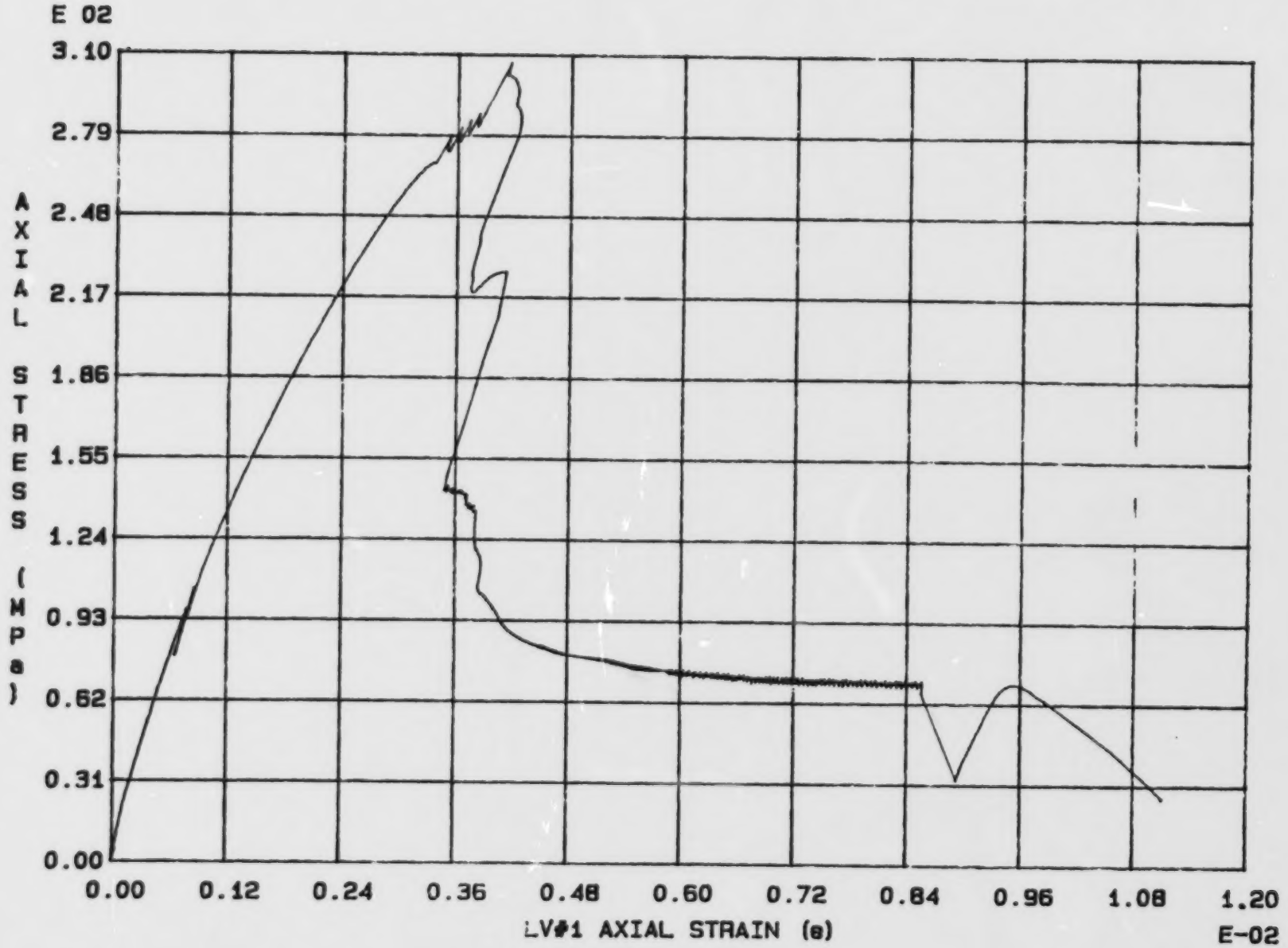

E 02
3.10
2.79
2.48
2.17
1.86
1.55
1.24
0.93
0.62
0.31
0.00
AXIAL STRESS (MPa)
0.00
0.12
0.24
0.36
0.48
0.60
0.72
0.84
0.96
1.08
1.20
LV#1 AXIAL STRAIN (e)
E-02

Fig. E-13 E26T

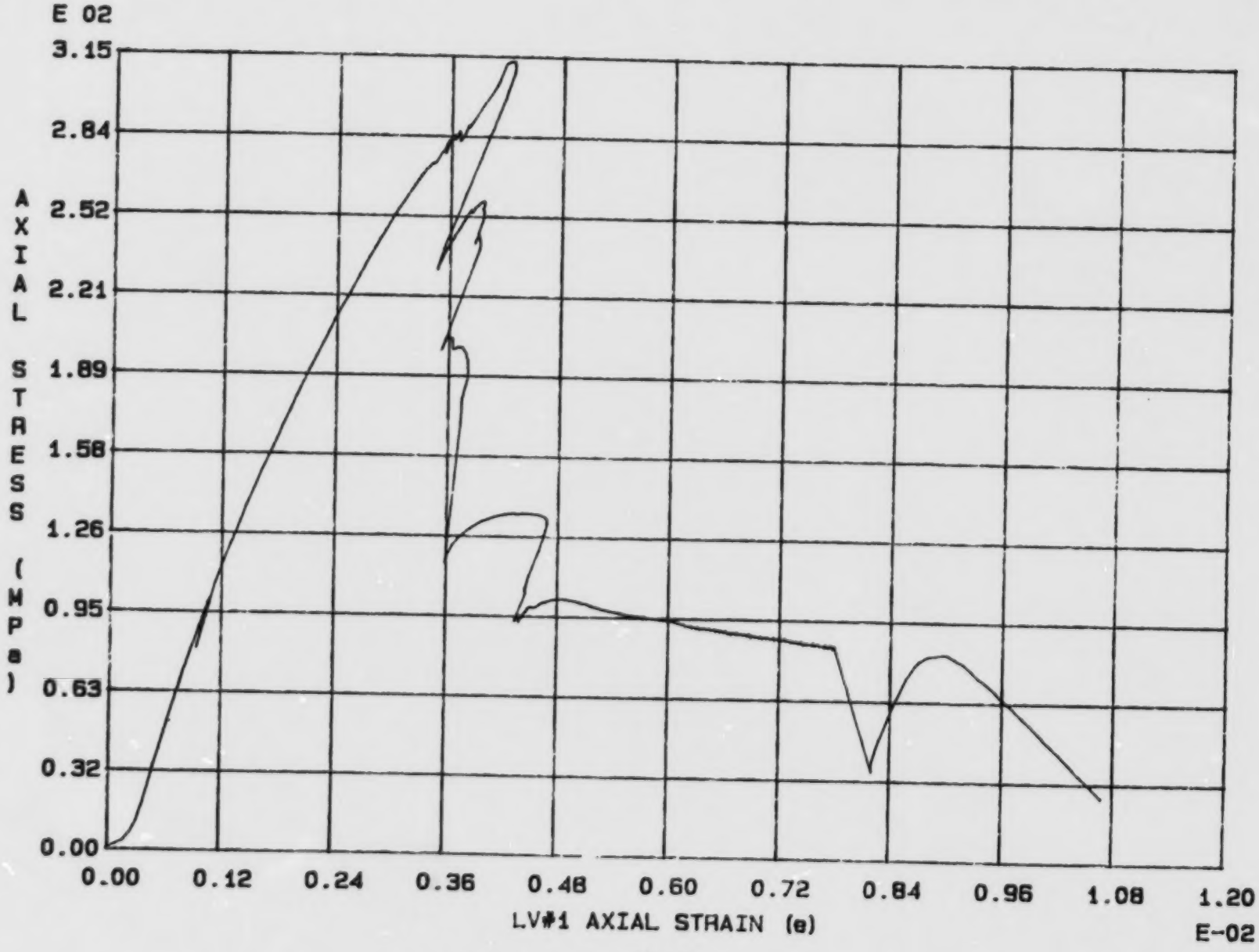

E 02
3.15
2.84
2.52
2.21
1.89
1.58
1.26
0.95
0.63
0.32
0.00
AXIAL STRESS (MPa)
0.00
0.12
0.24
0.36
0.48
0.60
0.72
0.84
0.96
1.08
1.20
LV#1 AXIAL STRAIN (e)
E-02

Fig. E-14 E28T

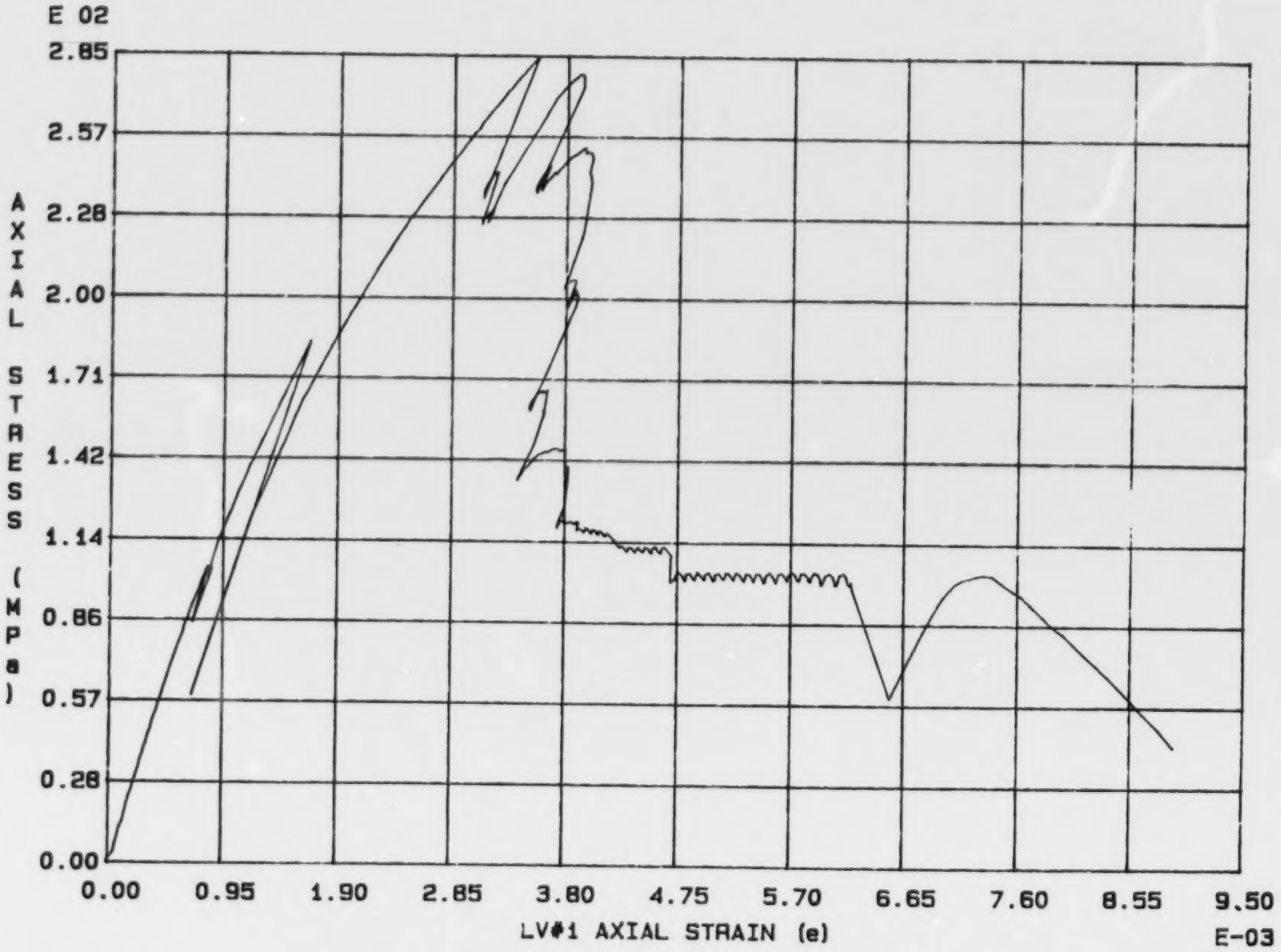

E 02
2.85
2.57
2.28
2.00
1.71
1.42
1.14
0.86
0.57
0.28
0.00
AXIAL STRESS (MPa)
0.00
0.95
1.90
2.85
3.80
4.75
5.70
6.65
7.60
8.55
9.50
LV#1 AXIAL STRAIN (e)
E-03

Fig. E-15 E30T

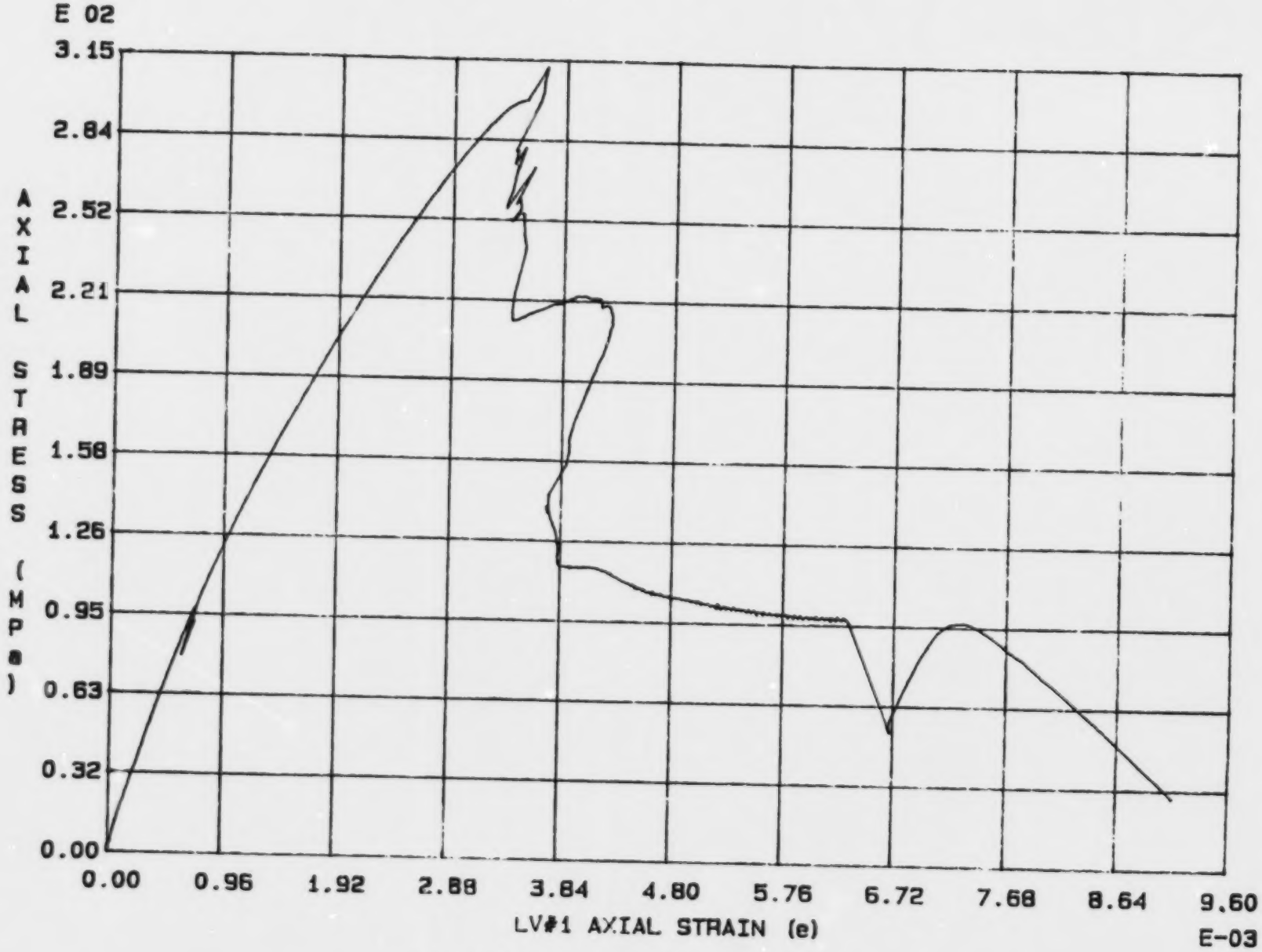

E 02
3.15
2.84
2.52
2.21
1.89
1.58
1.26
0.95
0.63
0.32
0.00
AXIAL STRESS (MPa)
0.00
0.96
1.92
2.88
3.84
4.80
5.76
6.72
7.68
8.64
9.60
LV#1 AXIAL STRAIN (e)
E-03

Fig. E-16 E32T

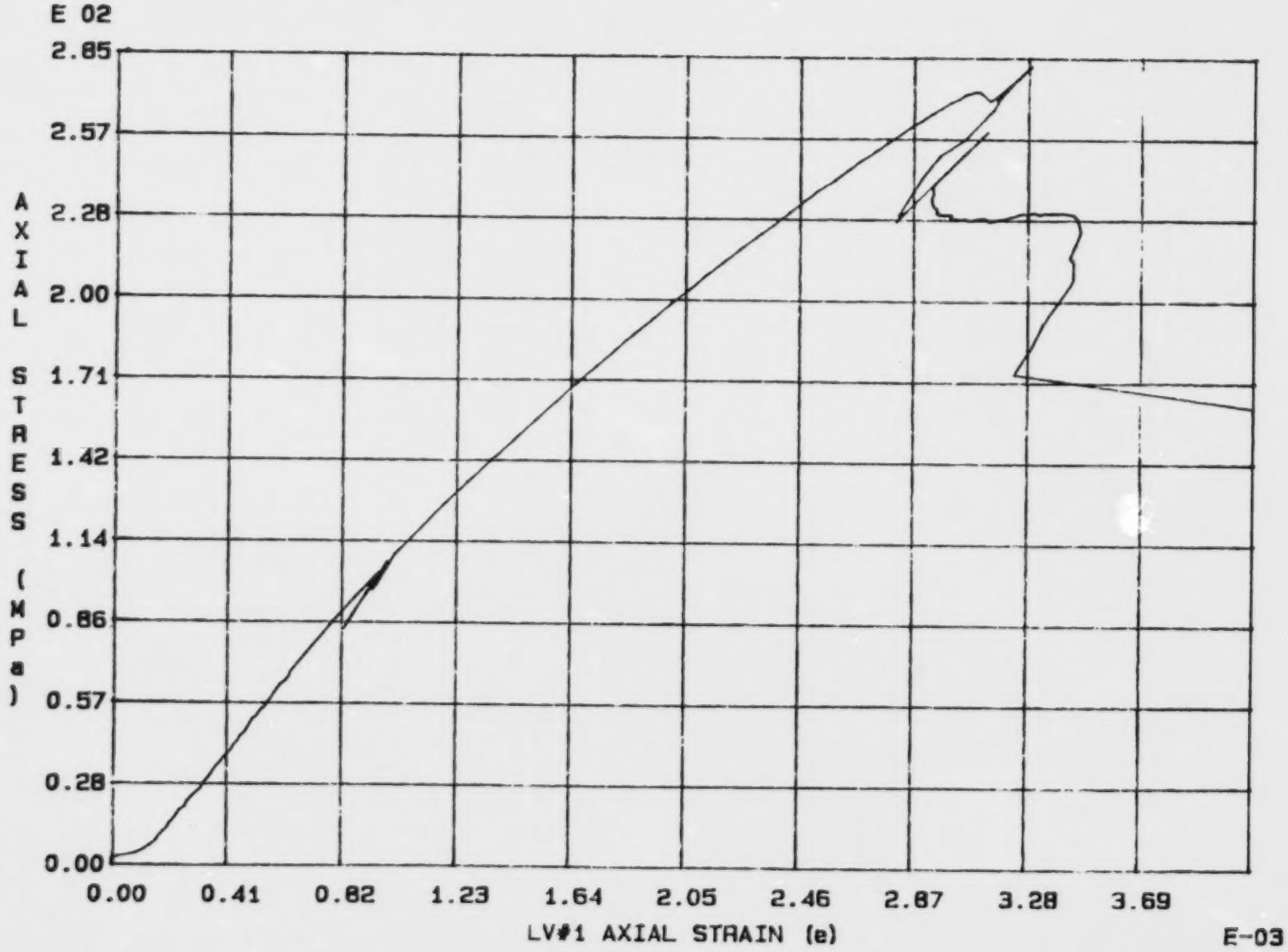

E 02
2.85
2.57
2.28
2.00
1.71
1.42
1.14
0.86
0.57
0.28
0.00
AXIAL STRESS (MPa)
0.00
0.41
0.82
1.23
1.64
2.05
2.46
2.87
3.28
3.69
LV#1 AXIAL STRAIN (e)
E-03

Fig. E-17 E34T

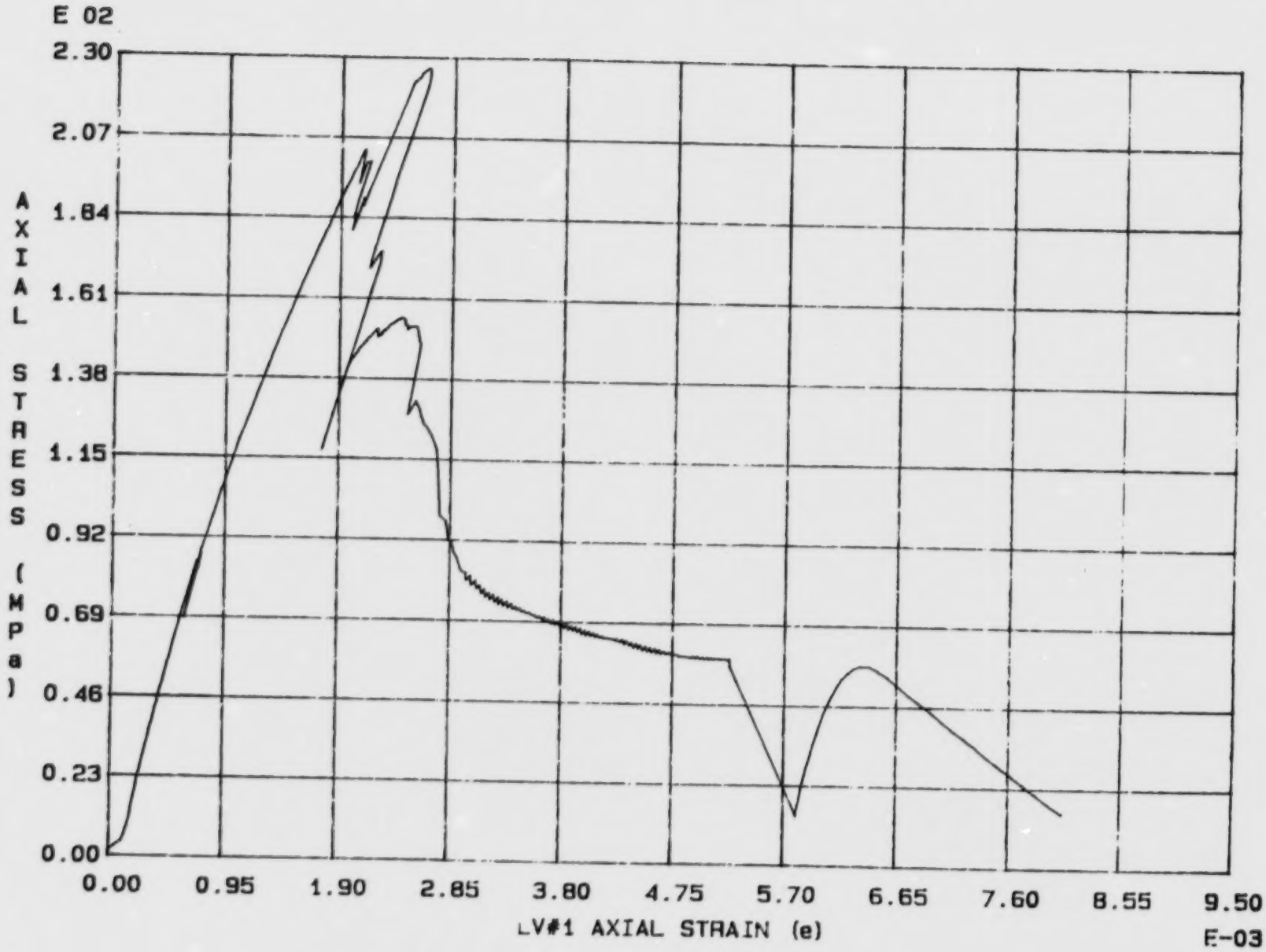

E 02
2.30
2.07
1.84
1.61
1.38
1.15
0.92
0.69
0.46
0.23
0.00
AXIAL STRESS (MPa)
0.00
0.95
1.90
2.85
3.80
4.75
5.70
6.65
7.60
8.55
9.50
LV#1 AXIAL STRAIN (e)
E-03

Fig. E-18 E36T

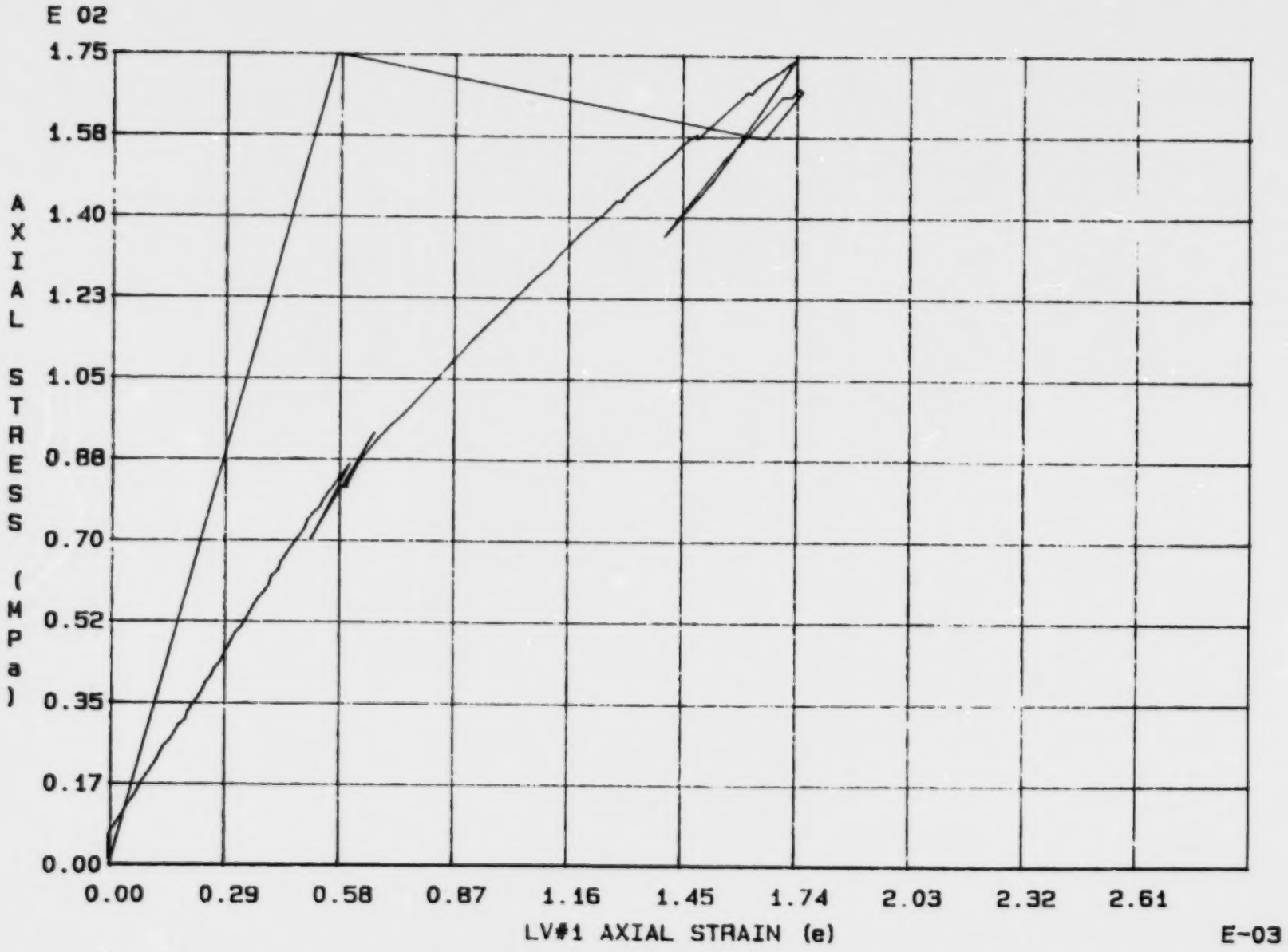

E 02
1.75
1.58
1.40
1.23
1.05
0.88
0.70
0.52
0.35
0.17
0.00
AXIAL STRESS (MPa)
0.00
0.29
0.58
0.87
1.16
1.45
1.74
2.03
2.32
2.61
LV#1 AXIAL STRAIN (e)
E-03

Fig. E-19 E38T

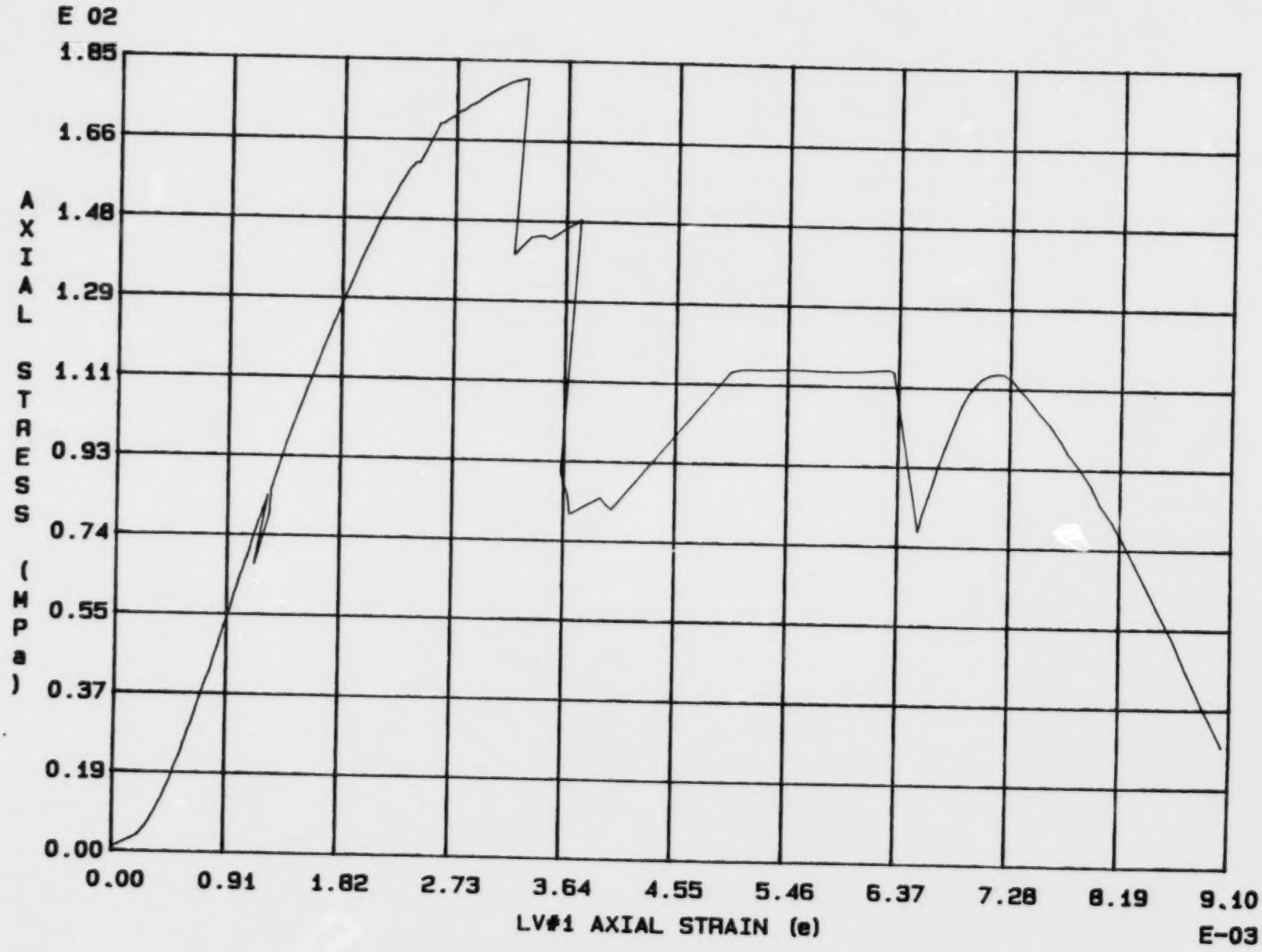

E 02
1.85
1.66
1.48
1.29
1.11
0.93
0.74
0.55
0.37
0.19
0.00
AXIAL STRESS (MPa)
0.00
0.91
1.82
2.73
3.64
4.55
5.46
6.37
7.28
8.19
9.10
E-03
LV#1 AXIAL STRAIN (e)

Fig. E-20 E40T

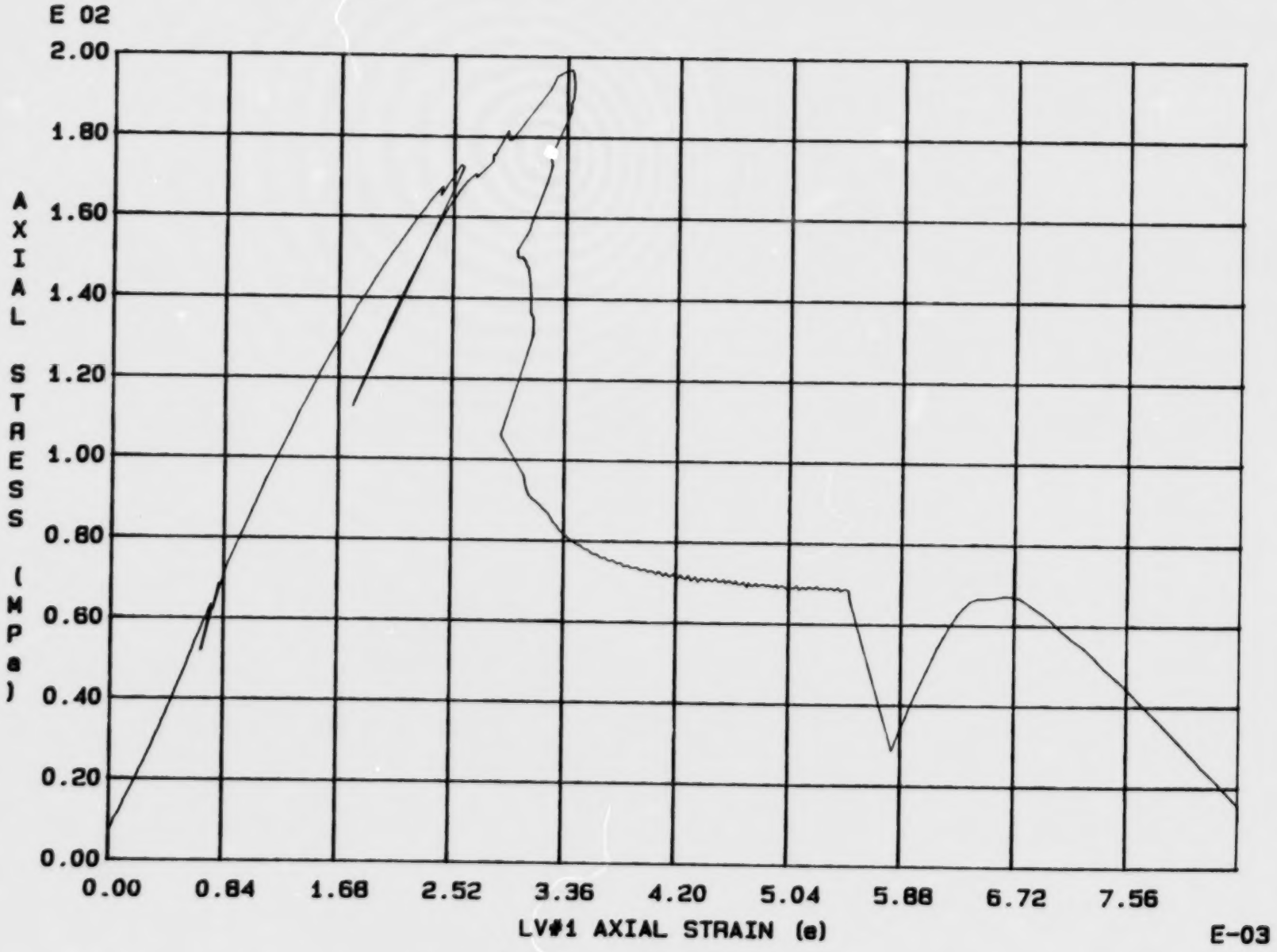

E 02
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
AXIAL STRESS (MPa)
0.00
0.84
1.68
2.52
3.36
4.20
5.04
5.88
6.72
7.56
LV#1 AXIAL STRAIN (e)
E-03

Fig. E-21 E42T

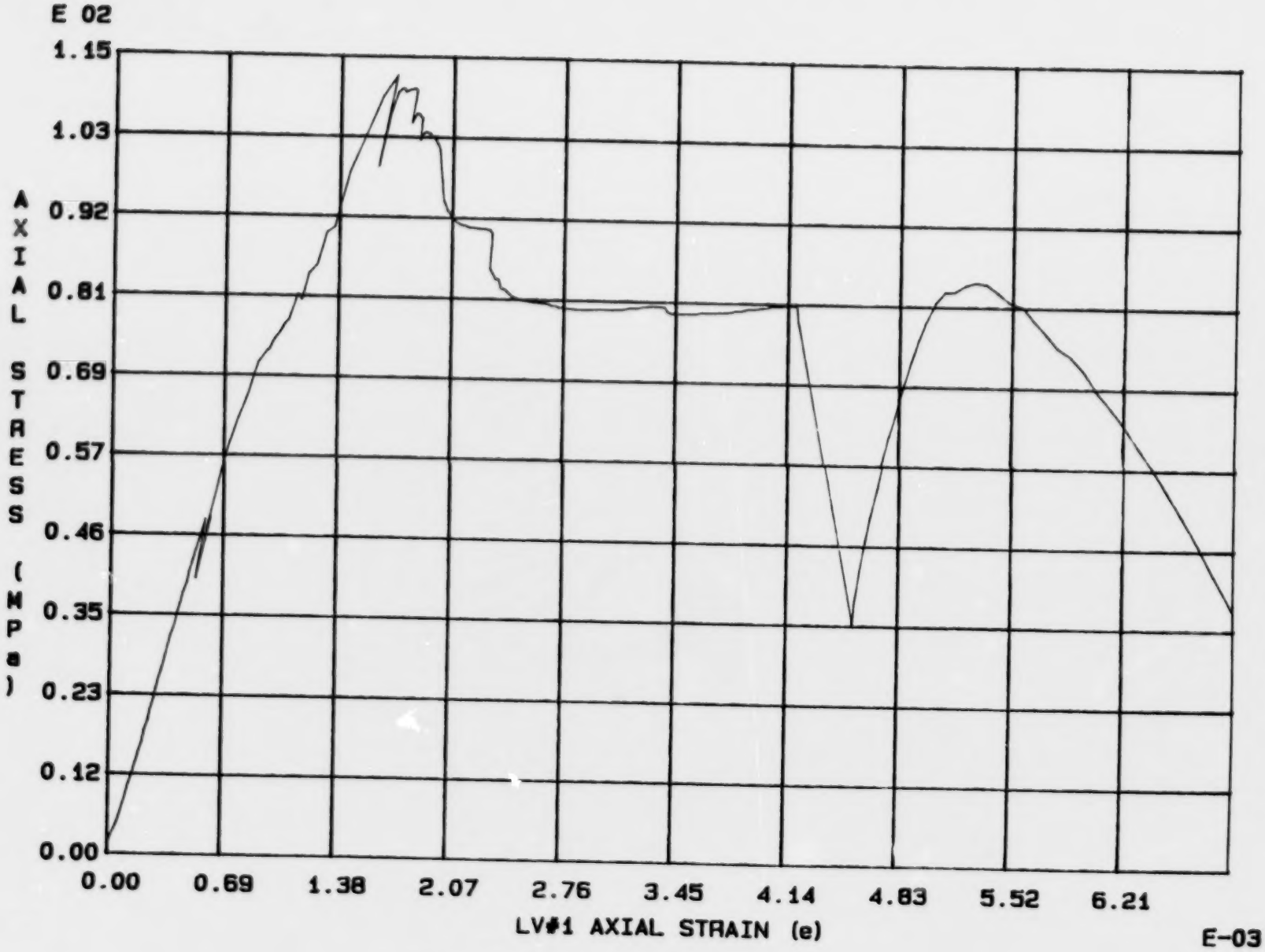

E 02
1.15
1.03
0.92
0.81
0.69
0.57
0.46
0.35
0.23
0.12
0.00
AXIAL STRESS (MPa)
0.00
0.69
1.38
2.07
2.76
3.45
4.14
4.83
5.52
6.21
LV#1 AXIAL STRAIN (e)
E-03

Fig. E-22 E44T

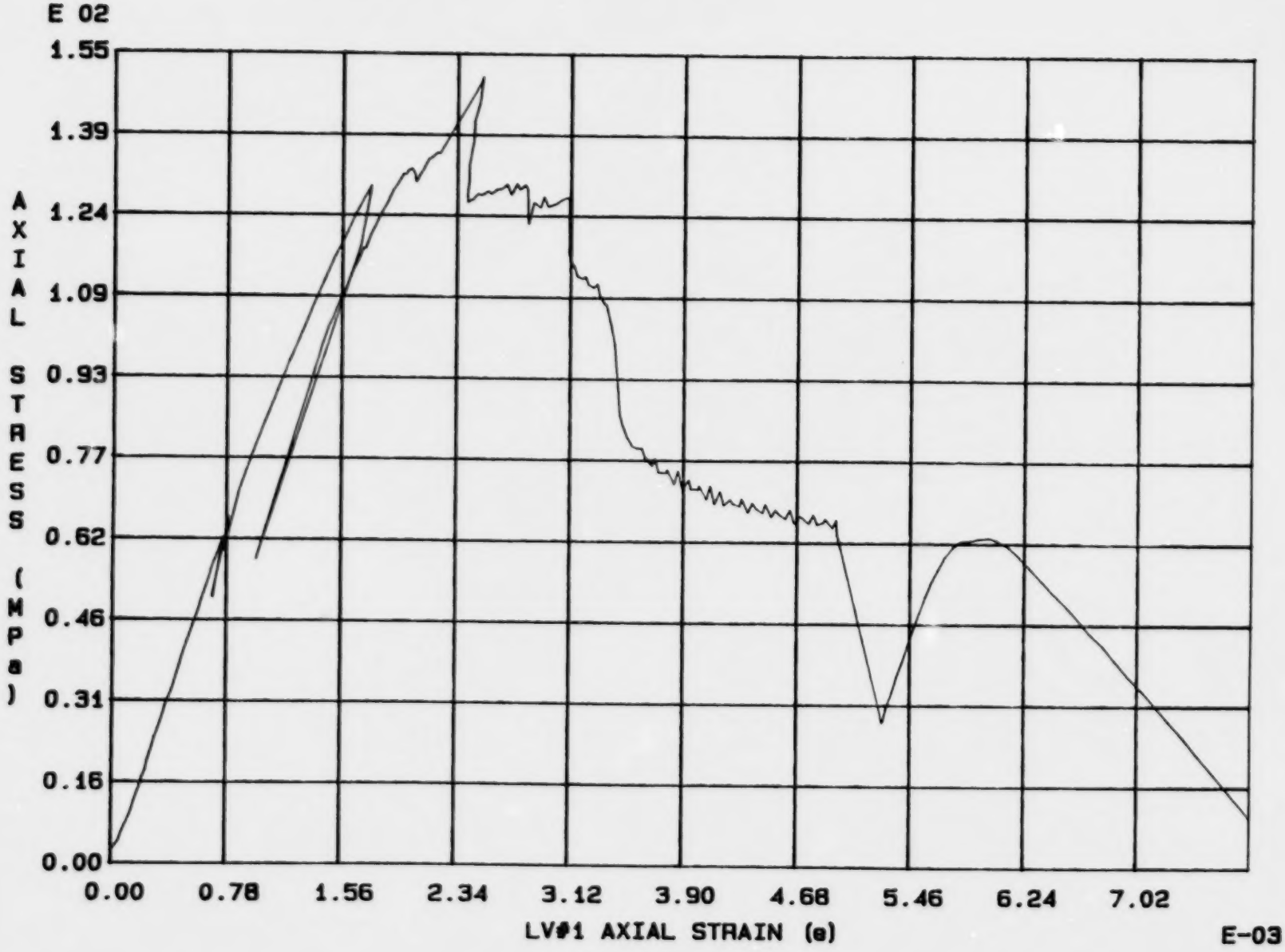

E 02
1.55
1.39
1.24
1.09
0.93
0.77
0.62
0.46
0.31
0.16
0.00
AXIAL STRESS (MPa)
0.00
0.78
1.56
2.34
3.12
3.90
4.68
5.46
6.24
7.02
LV#1 AXIAL STRAIN (e)
E-03

Fig. E-23 E46T

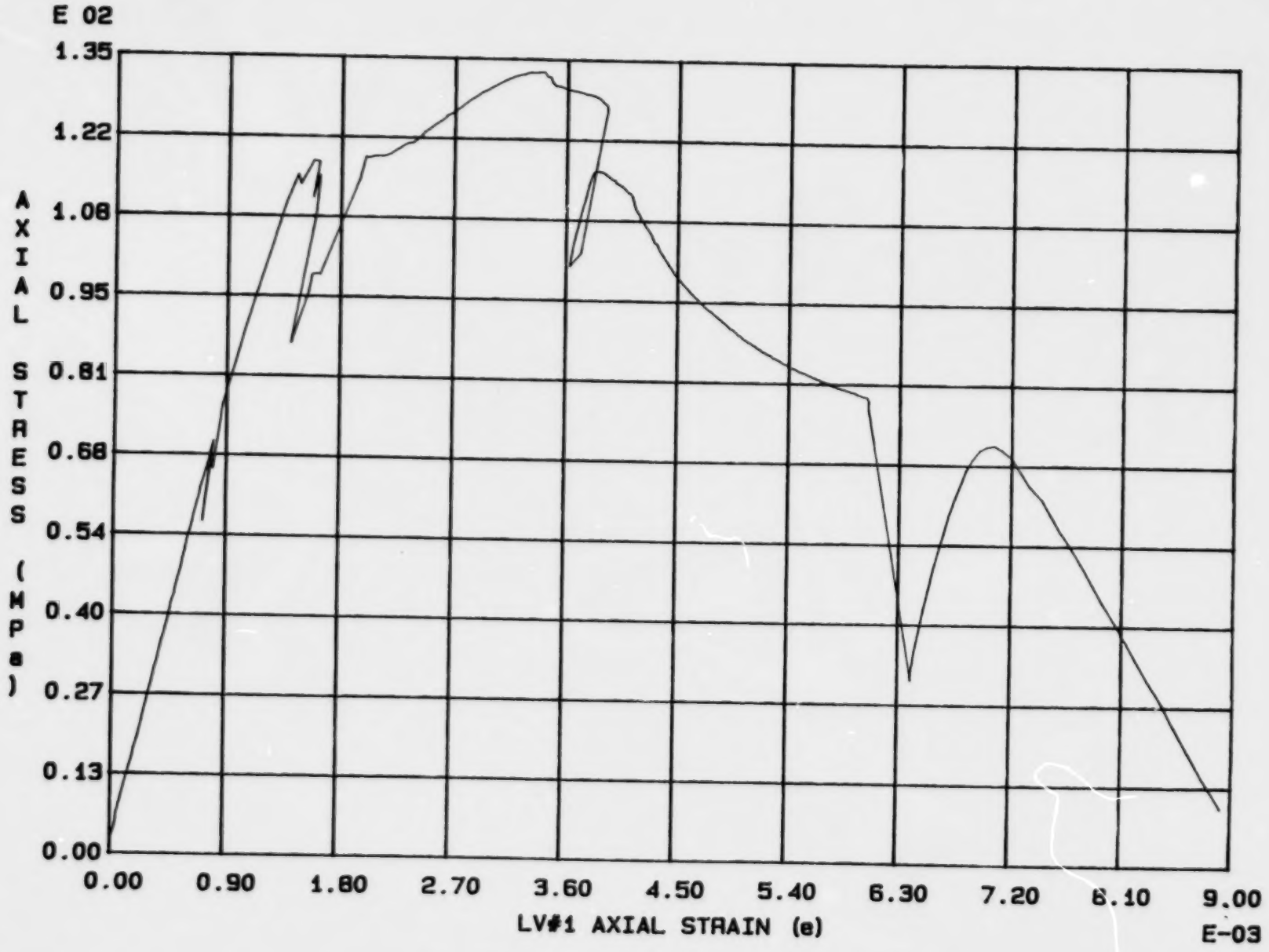

E 02
1.35
1.22
1.08
0.95
0.81
0.68
0.54
0.40
0.27
0.13
0.00
AXIAL STRESS (MPa)
0.00
0.90
1.80
2.70
3.60
4.50
5.40
6.30
7.20
8.10
9.00
E-03
LV#1 AXIAL STRAIN (e)

Fig. E-24 E48T

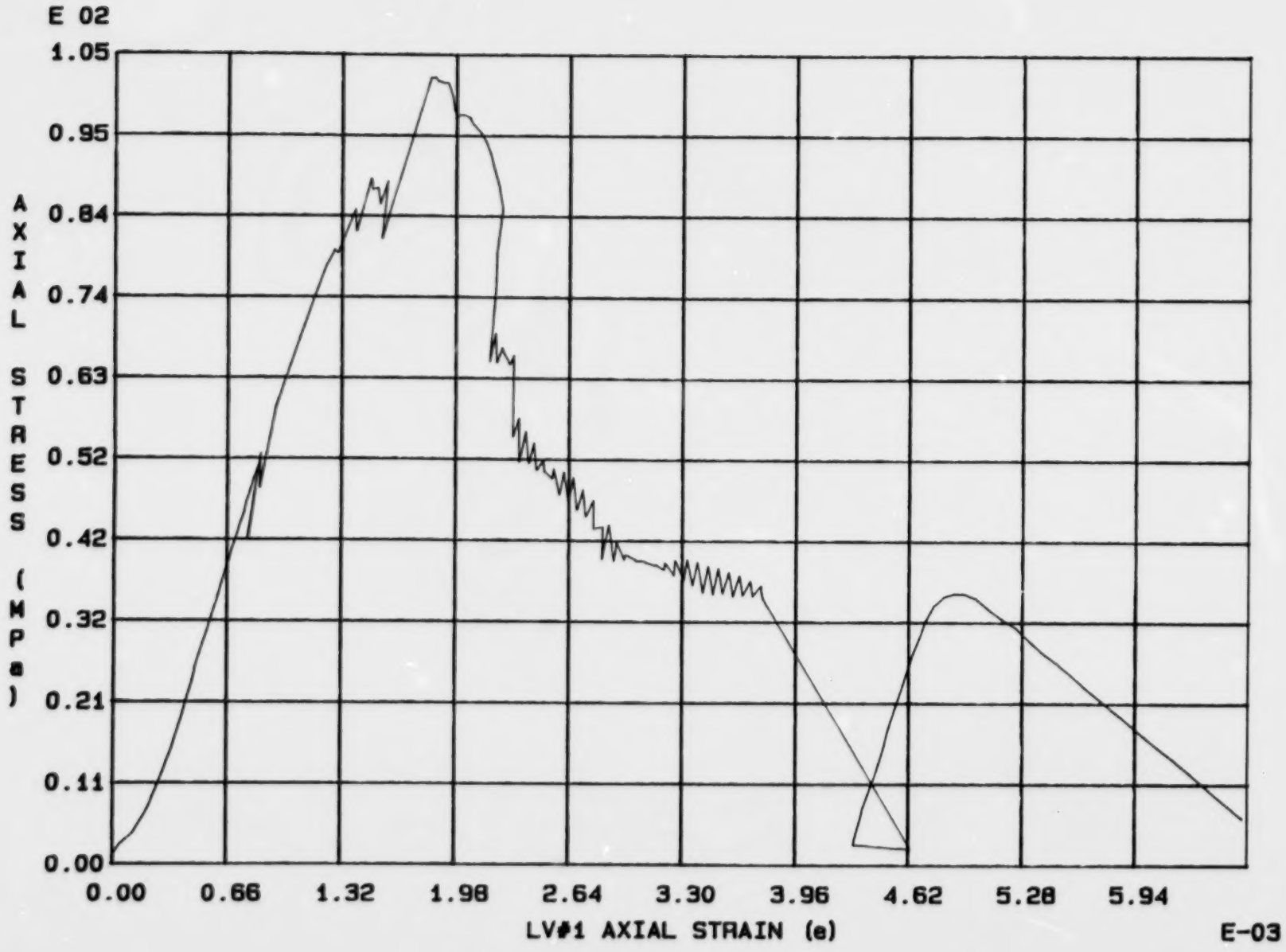

E 02
1.05
0.95
0.84
0.74
0.63
0.52
0.42
0.32
0.21
0.11
0.00
AXIAL STRESS (MPa)
0.00
0.66
1.32
1.98
2.64
3.30
3.96
4.62
5.28
5.94
LV#1 AXIAL STRAIN (e)
E-03

Fig. E-25 E50T

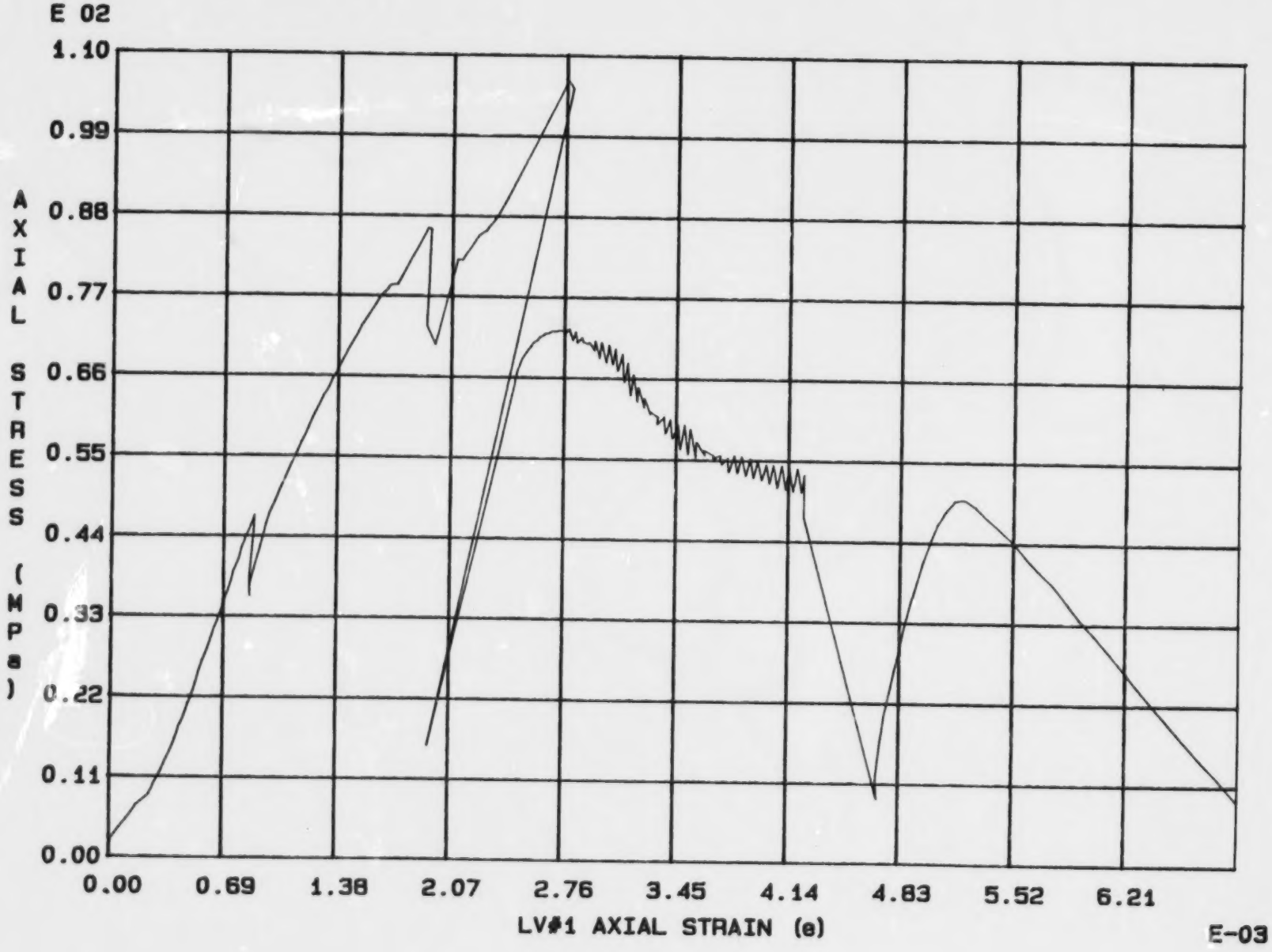

E 02
1.10
0.99
0.88
0.77
0.66
0.55
0.44
0.33
0.22
0.11
0.00
AXIAL STRESS (MPa)
0.00
0.69
1.38
2.07
2.76
3.45
4.14
4.83
5.52
6.21
LV#1 AXIAL STRAIN (e)
E-03

Fig. E-26 E52T

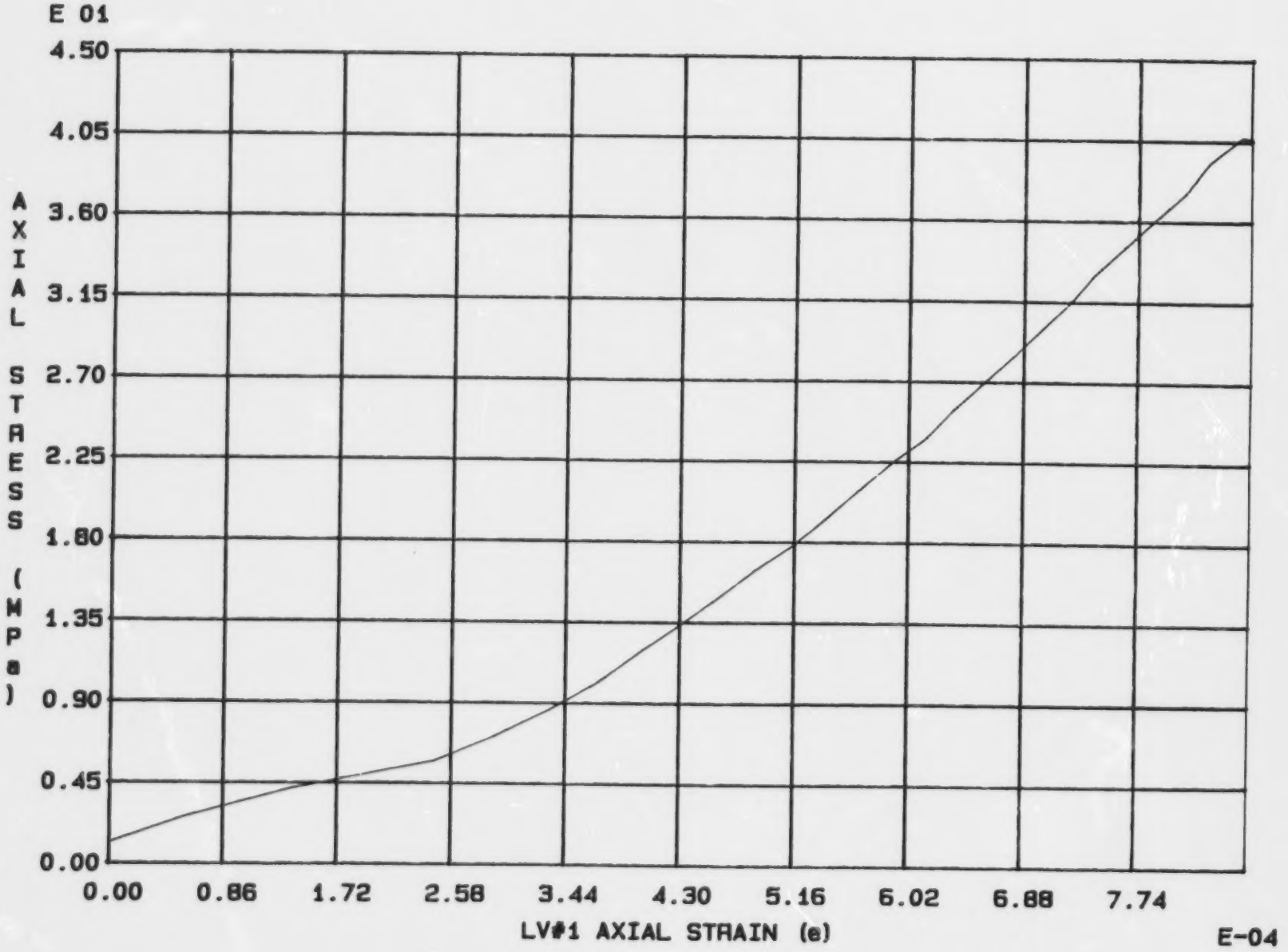

E 01
4.50
4.05
3.60
3.15
2.70
2.25
1.80
1.35
0.90
0.45
0.00
AXIAL STRESS (MPa)
0.00
0.86
1.72
2.58
3.44
4.30
5.16
6.02
6.88
7.74
LV#1 AXIAL STRAIN (e)
E-04

Fig. E-27 E54T

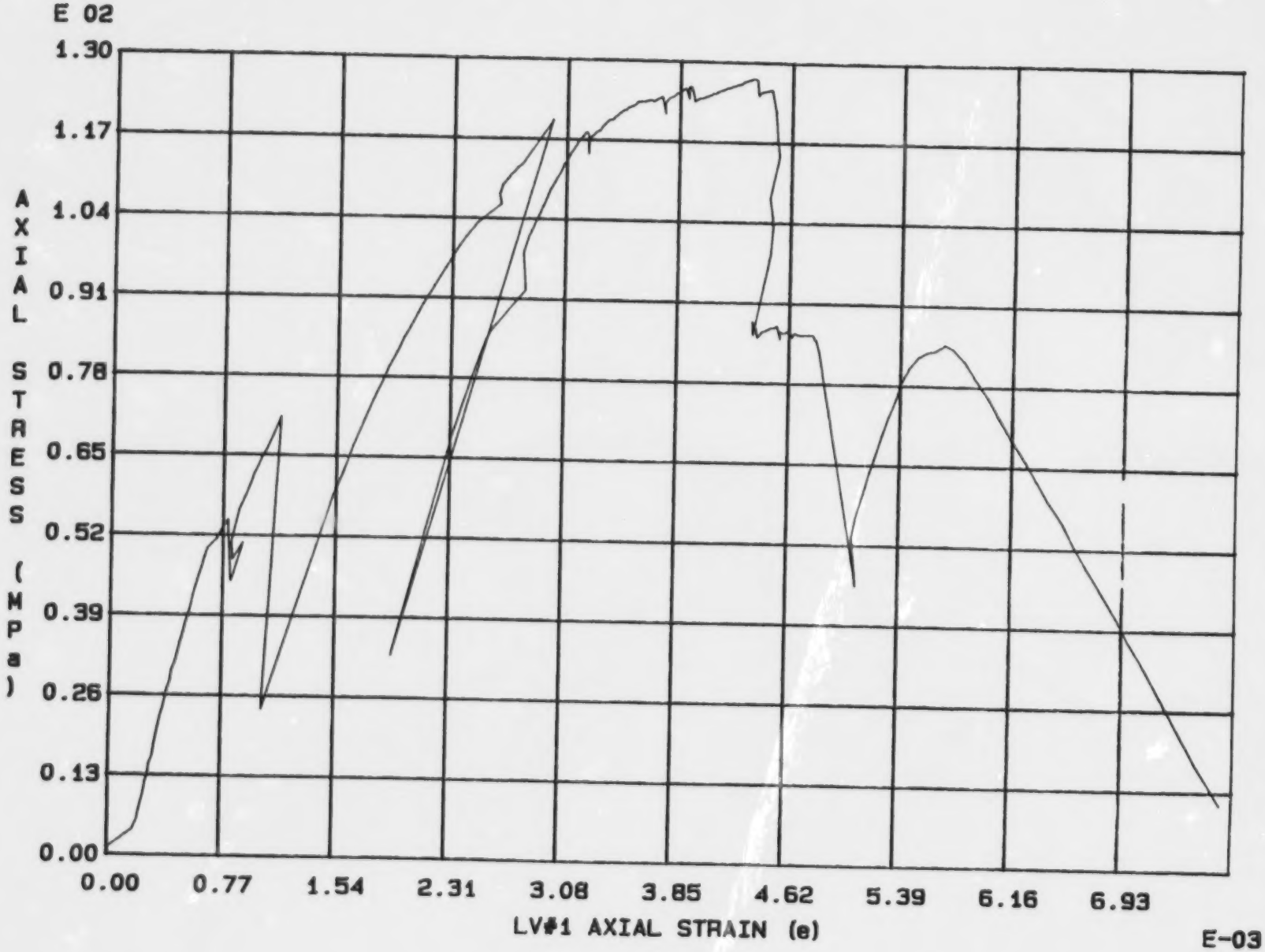

E 02
1.30
1.17
1.04
0.91
0.78
0.65
0.52
0.39
0.26
0.13
0.00
AXIAL STRESS (MPa)
0.00
0.77
1.54
2.31
3.08
3.85
4.62
5.39
6.16
6.93
LV#1 AXIAL STRAIN (e)
E-03

Fig. E-28 E56T

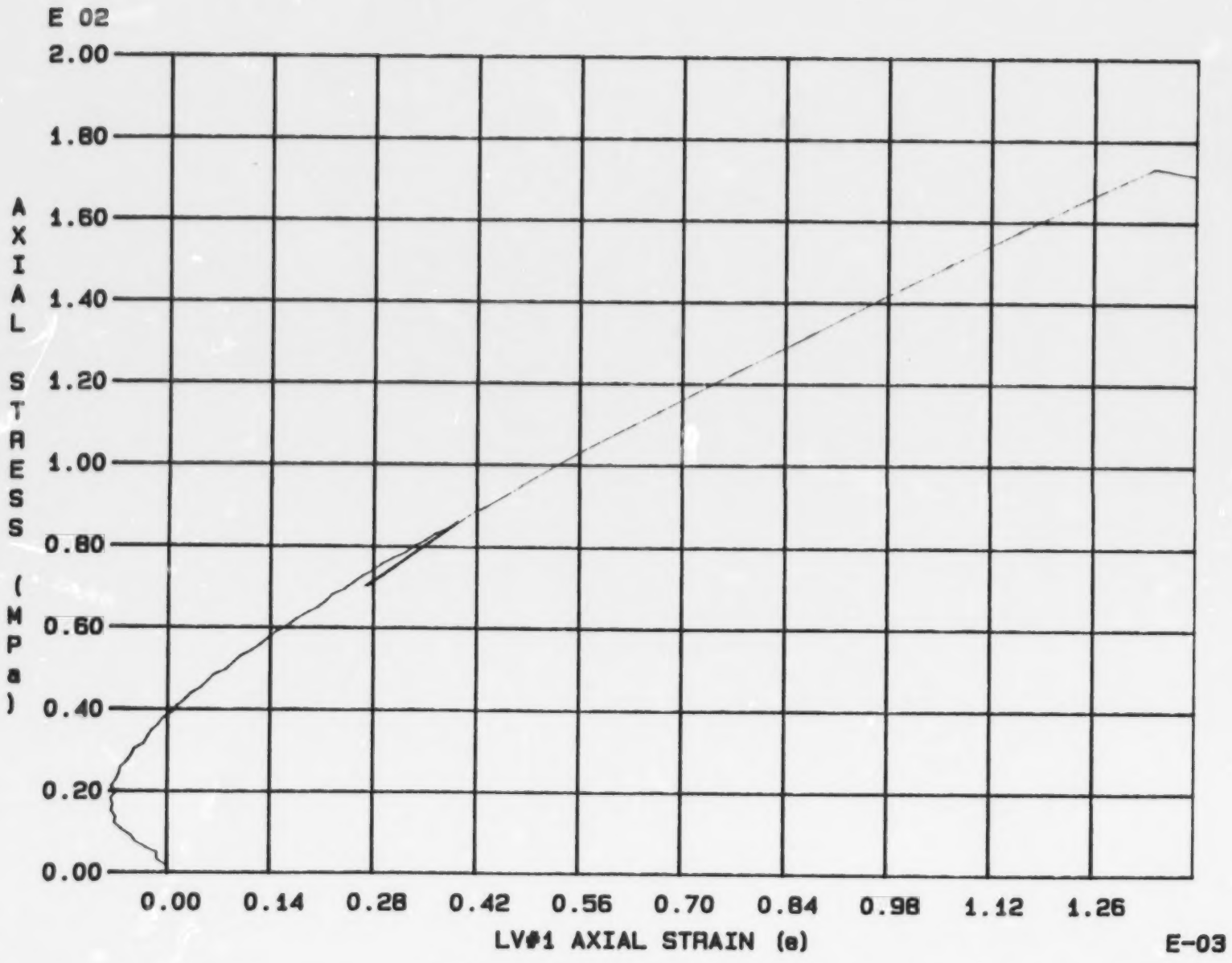

E 02
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
AXIAL STRESS (MPa)
0.00
0.14
0.28
0.42
0.56
0.70
0.84
0.98
1.12
1.26
LV#1 AXIAL STRAIN (e)
E-03

Fig. E-29 E61M

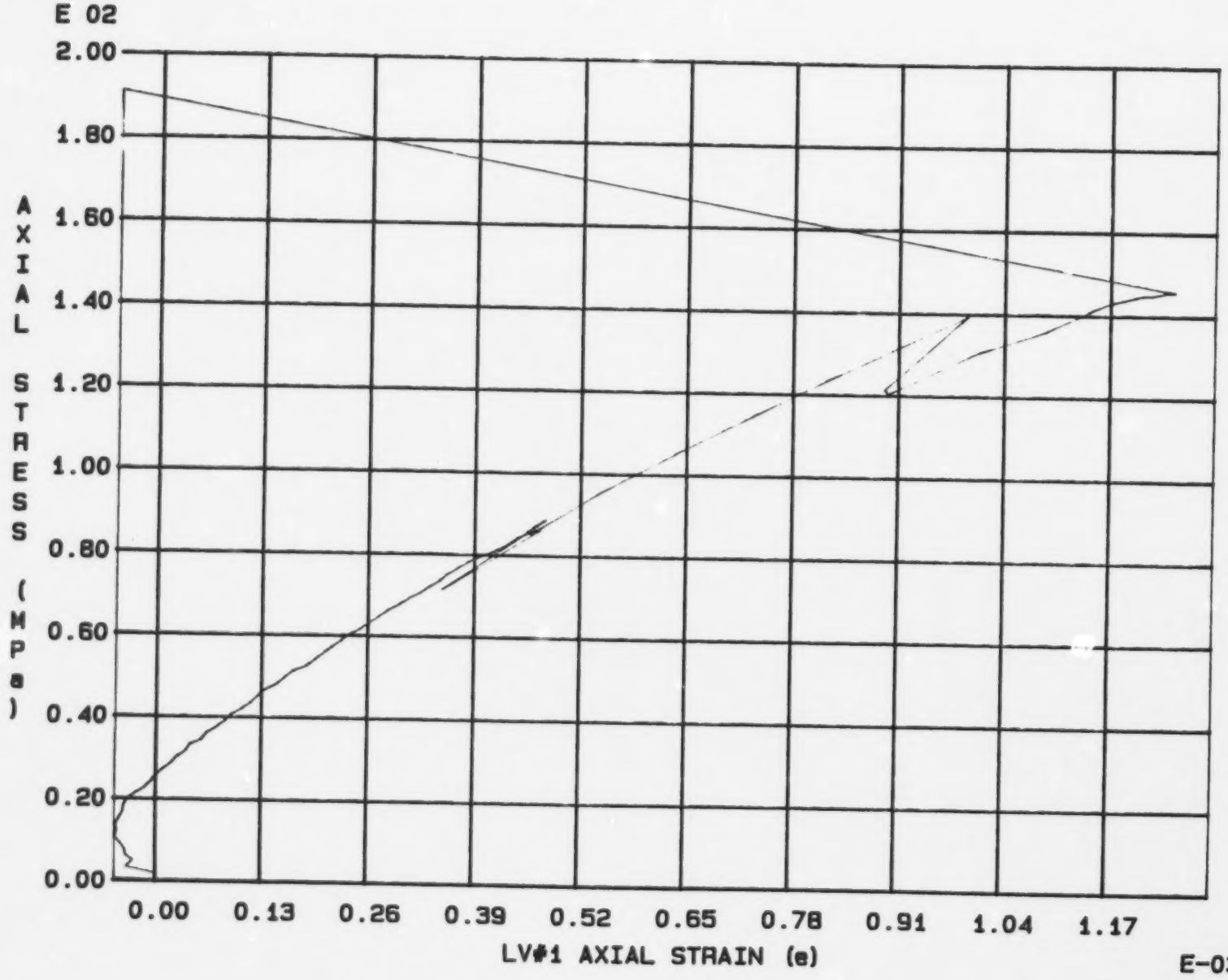

E 02
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
AXIAL STRESS (MPa)
0.00
0.13
0.26
0.39
0.52
0.65
0.78
0.91
1.04
1.17
LV#1 AXIAL STRAIN (e)
E-03

Fig. E-30 E62M

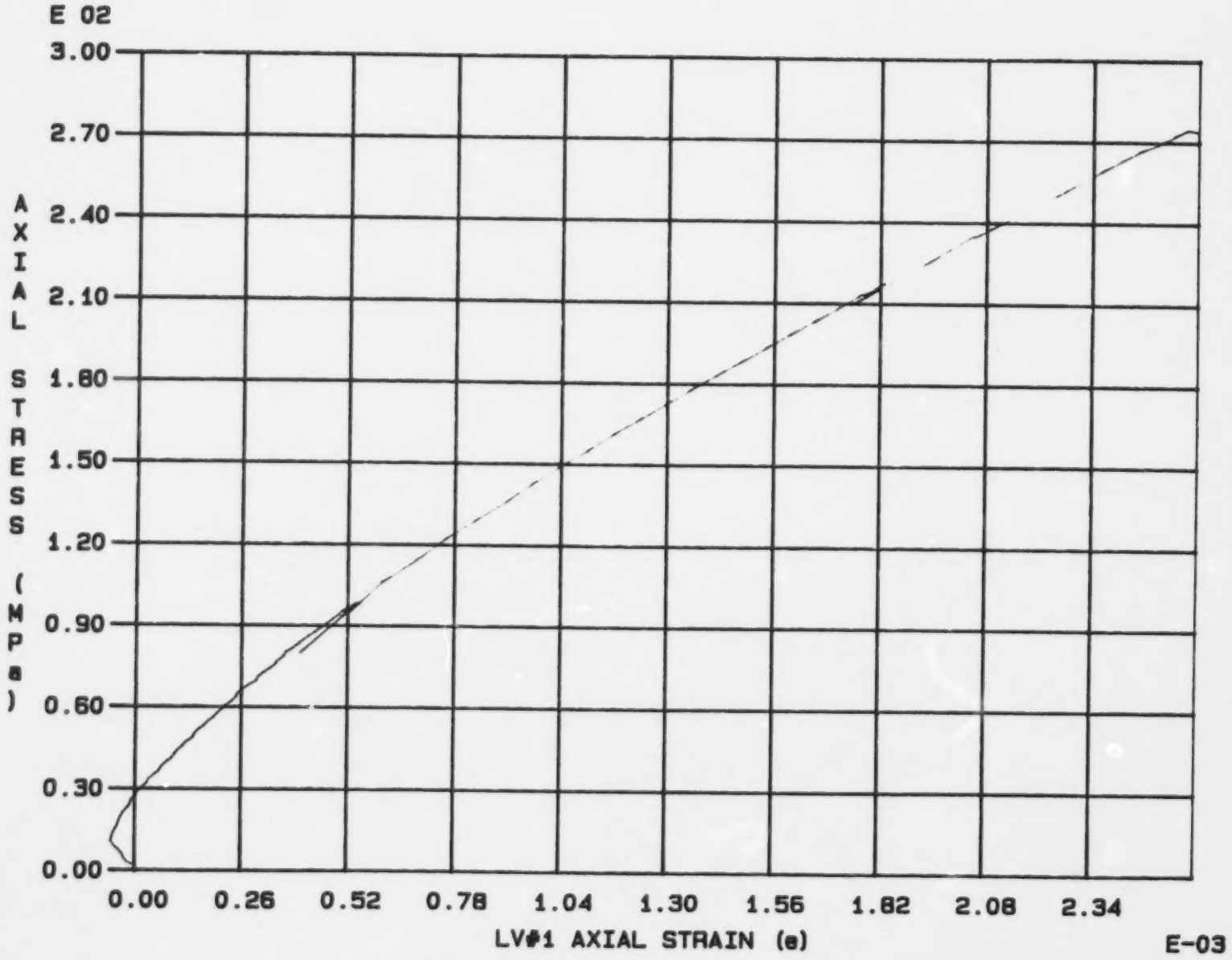

E 02
3.00
2.70
2.40
2.10
1.80
1.50
1.20
0.90
0.60
0.30
0.00
AXIAL STRESS (MPa)
0.00
0.26
0.52
0.78
1.04
1.30
1.56
1.82
2.08
2.34
LV#1 AXIAL STRAIN (e)
E-03

Fig. E-31 E63M

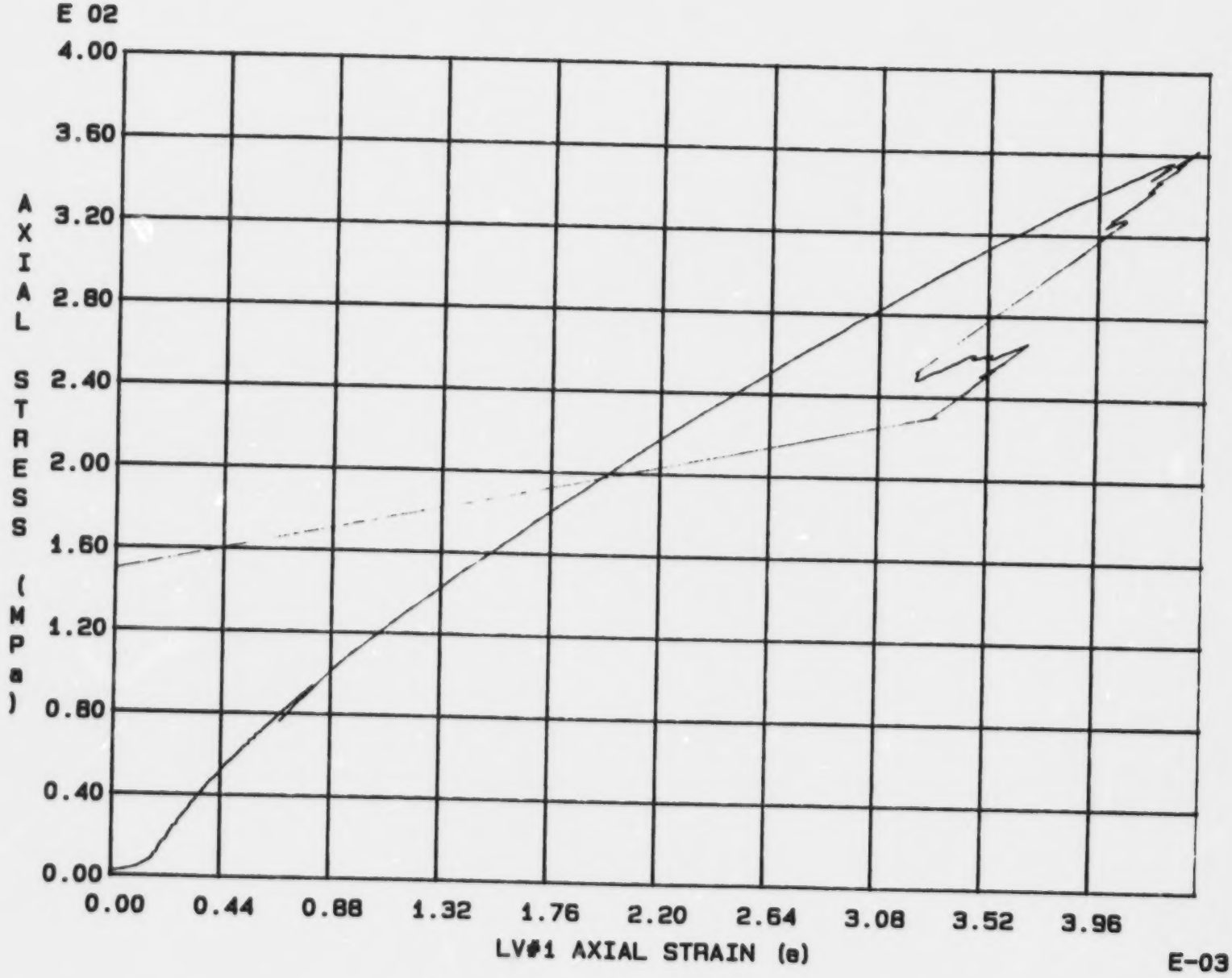

E 02
4.00
3.60
3.20
2.80
2.40
2.00
1.60
1.20
0.80
0.40
0.00
AXIAL STRESS (MPa)
0.00
0.44
0.88
1.32
1.76
2.20
2.64
3.08
3.52
3.96
LV#1 AXIAL STRAIN (e)
E-03

Fig. E-32 E64M

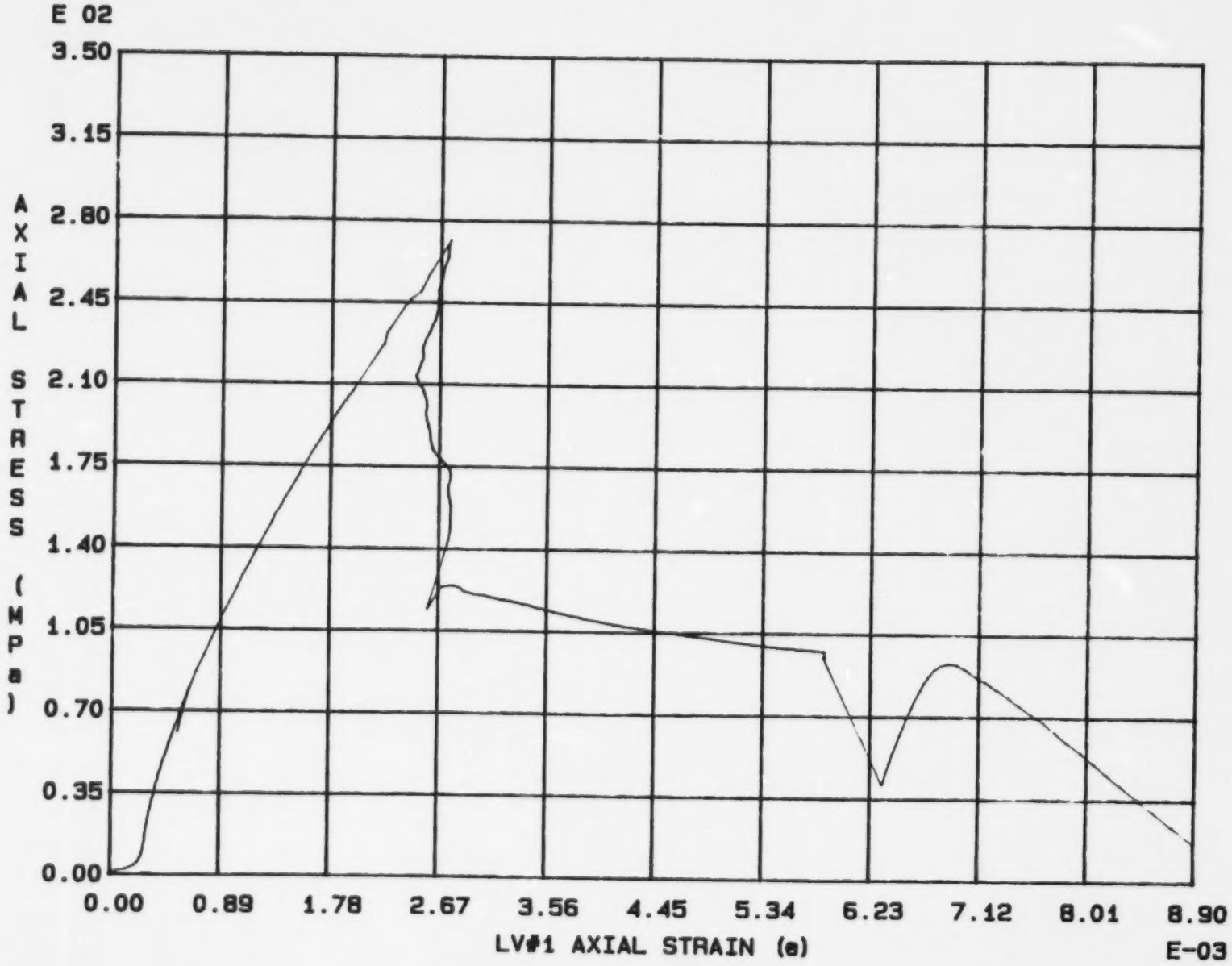

E 02
3.50
3.15
2.80
2.45
2.10
1.75
1.40
1.05
0.70
0.35
0.00
AXIAL STRESS (MPa)
0.00
0.89
1.78
2.67
3.56
4.45
5.34
6.23
7.12
8.01
8.90
LV#1 AXIAL STRAIN (e)
E-03

Fig. E-33 E65M

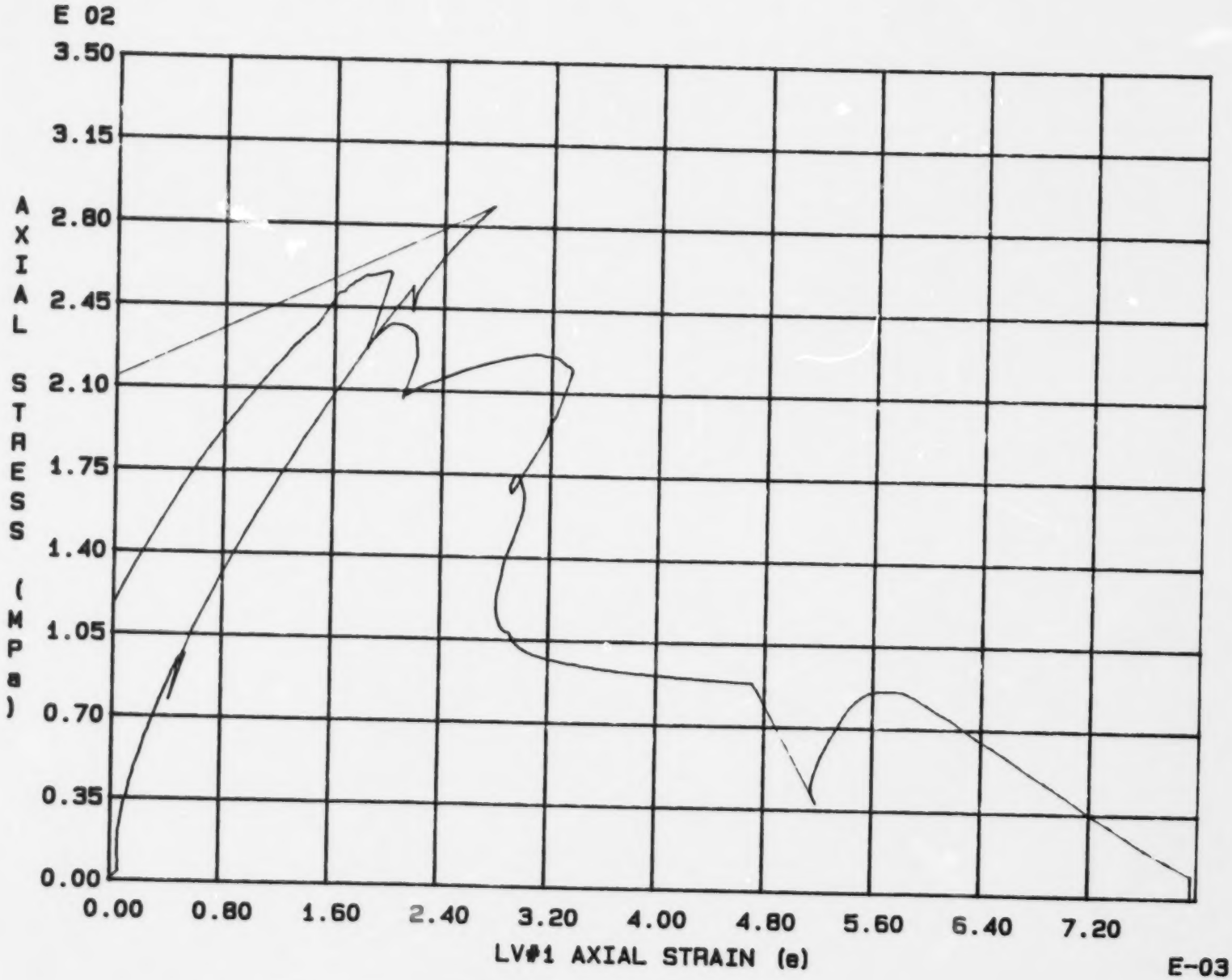

E 02
3.50
3.15
2.80
2.45
2.10
1.75
1.40
1.05
0.70
0.35
0.00
AXIAL STRESS (MPa)
0.00
0.80
1.60
2.40
3.20
4.00
4.80
5.60
6.40
7.20
LV#1 AXIAL STRAIN (e)
E-03

Fig. E-34 E66M

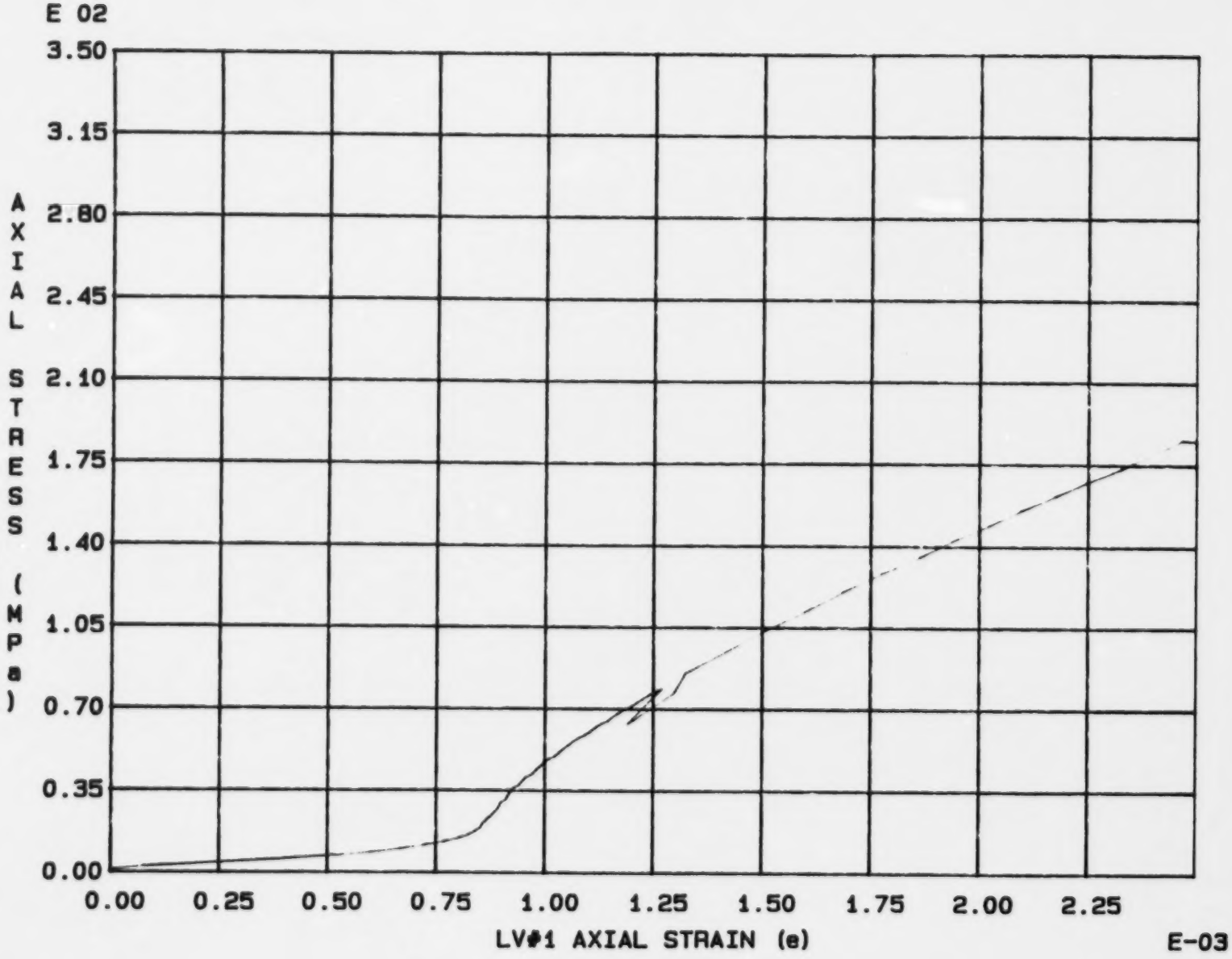

E 02
3.50
3.15
2.80
2.45
2.10
1.75
1.40
1.05
0.70
0.35
0.00
AXIAL STRESS (MPa)
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00
2.25
LV#1 AXIAL STRAIN (e)
E-03

Fig. E-35 E67M

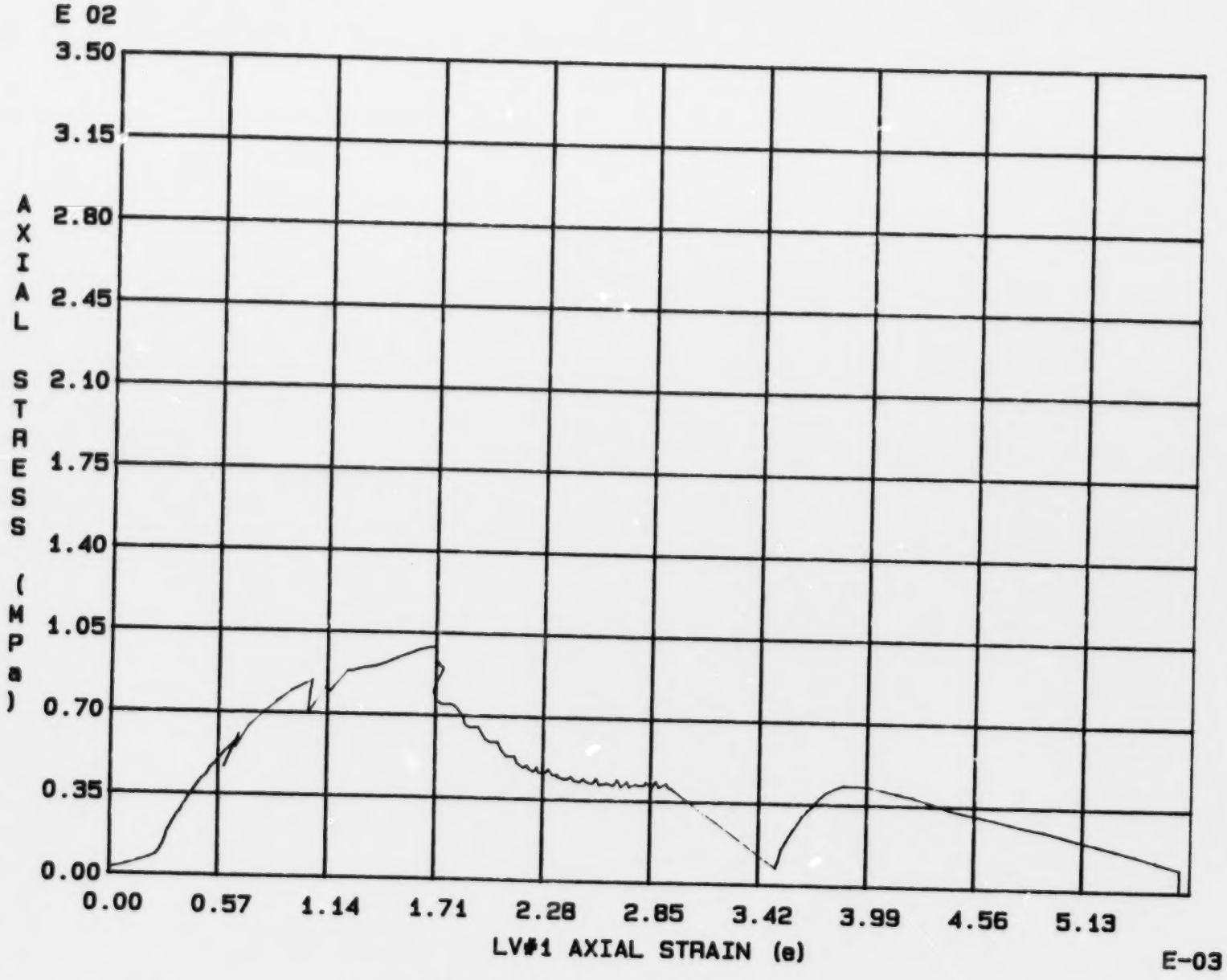

E 02
3.50
3.15
2.80
2.45
2.10
1.75
1.40
1.05
0.70
0.35
0.00
AXIAL STRESS (MPa)
0.00
0.57
1.14
1.71
2.28
2.85
3.42
3.99
4.56
5.13
LV#1 AXIAL STRAIN (e)
E-03

Fig. E-36 E68M

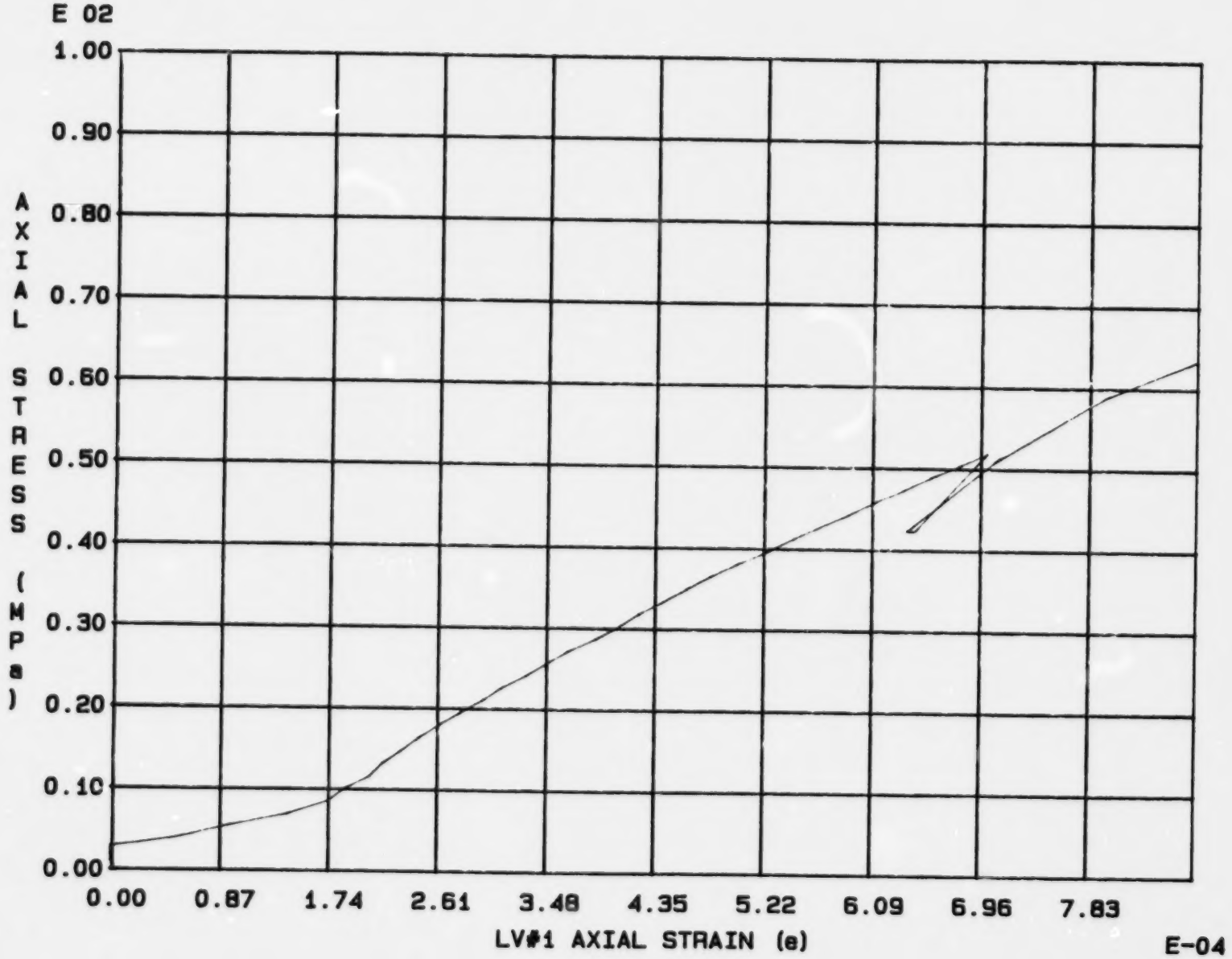

E 02
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
AXIAL STRESS (MPa)
0.00
0.87
1.74
2.61
3.48
4.35
5.22
6.09
6.96
7.83
LV#1 AXIAL STRAIN (e)
E-04

Fig. E-37 E69M

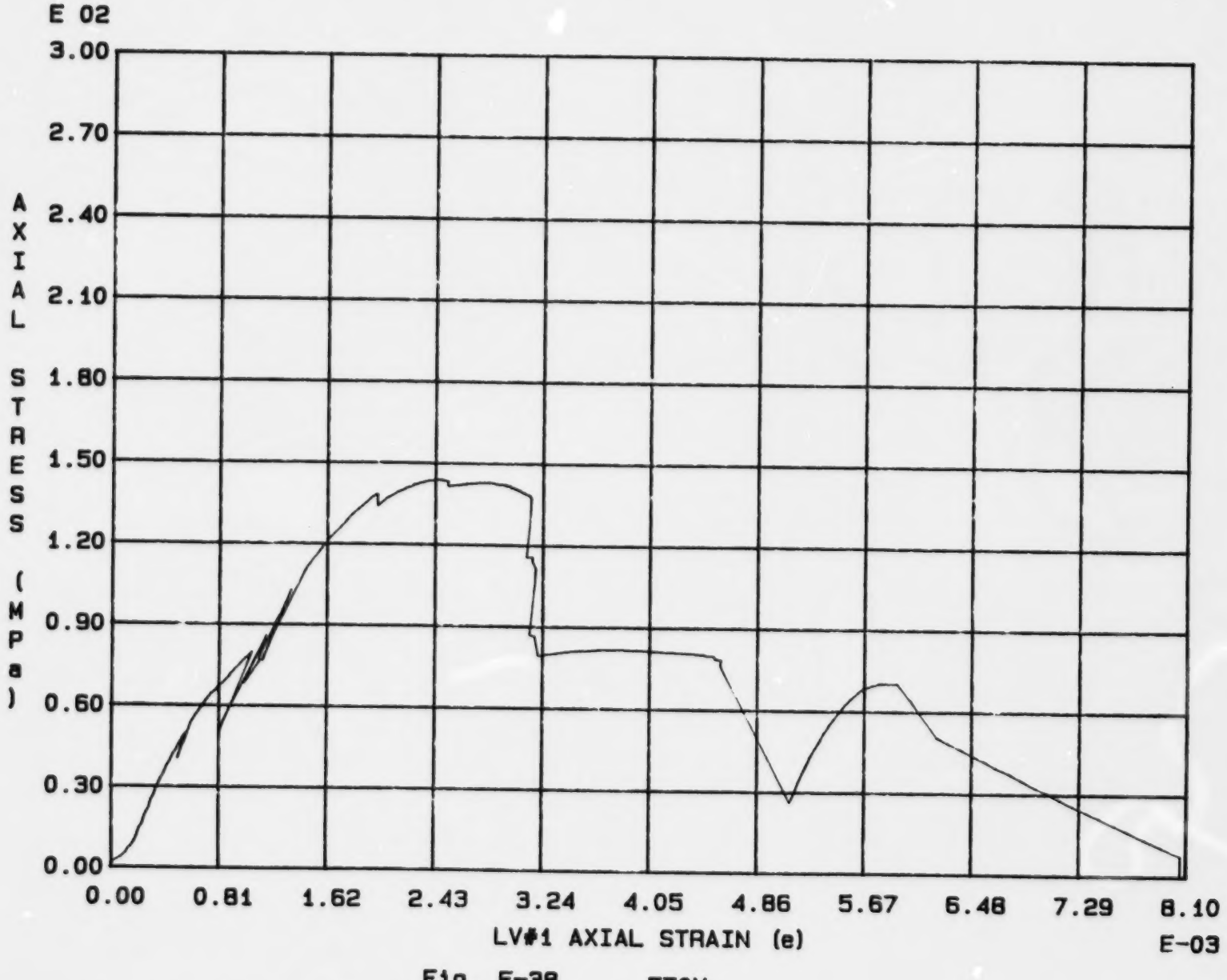

E 02
3.00
2.70
2.40
2.10
1.80
1.50
1.20
0.90
0.60
0.30
0.00
AXIAL STRESS (MPa)
0.00
0.81
1.62
2.43
3.24
4.05
4.86
5.67
6.48
7.29
8.10
LV#1 AXIAL STRAIN (e)
E-03

Fig. E-38 E70M

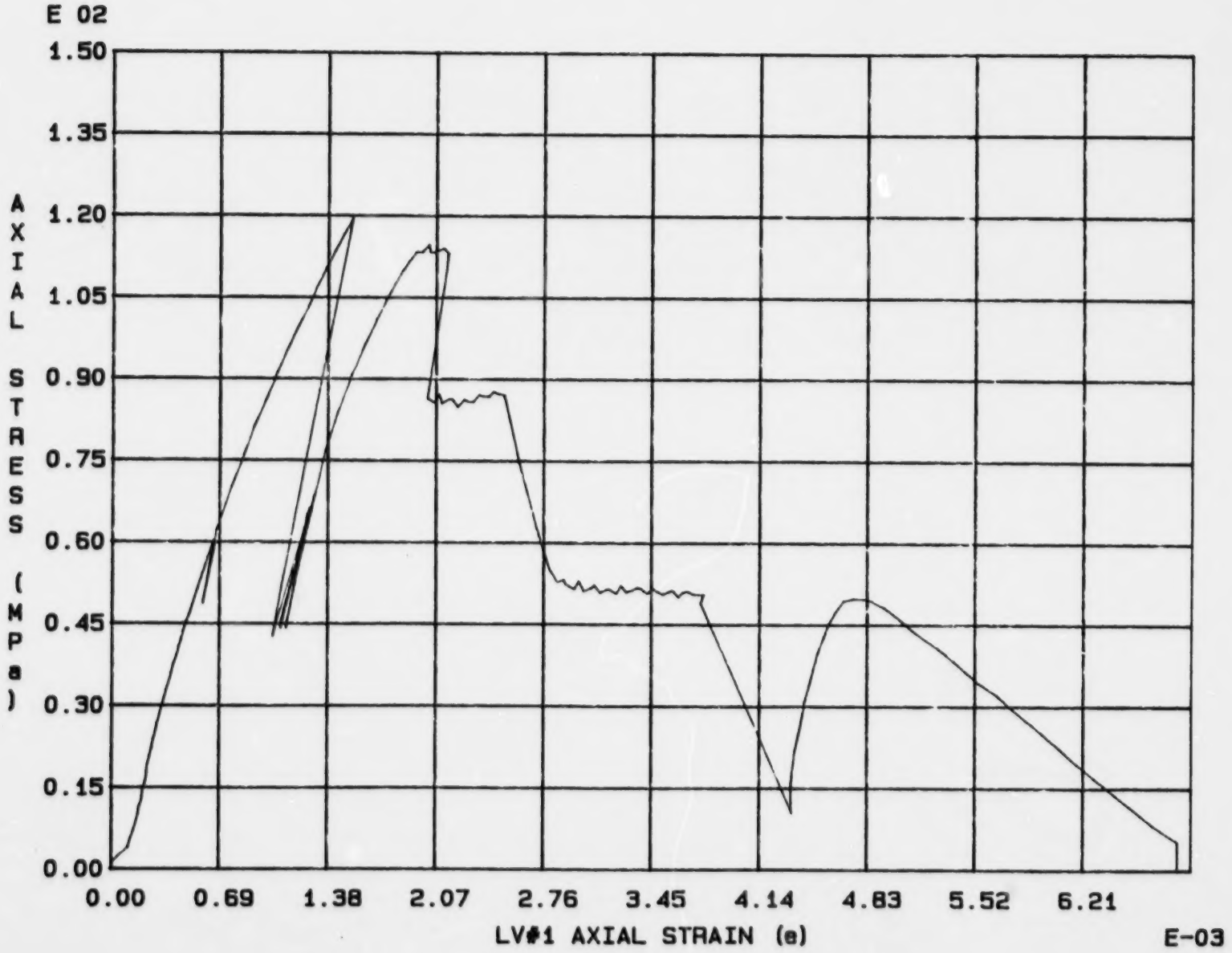

E 02
1.50
1.35
1.20
1.05
0.90
0.75
0.60
0.45
0.30
0.15
0.00
AXIAL STRESS (MPa)
0.00
0.69
1.38
2.07
2.76
3.45
4.14
4.83
5.52
6.21
LV#1 AXIAL STRAIN (e)
E-03

Fig. E-39 E71M

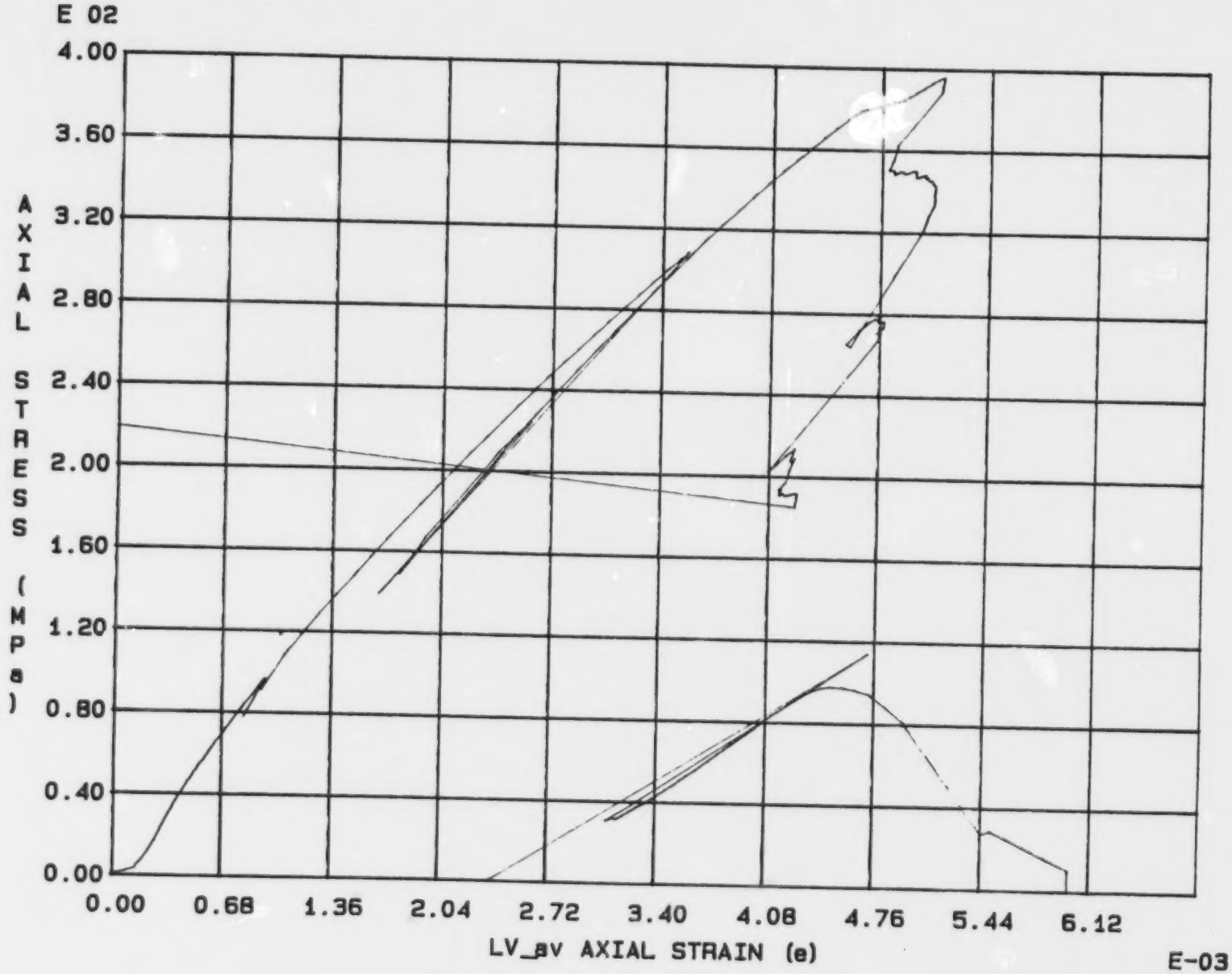

E 02
4.00
3.60
3.20
2.80
2.40
2.00
1.60
1.20
0.80
0.40
0.00
AXIAL STRESS (MPa)
0.00
0.68
1.36
2.04
2.72
3.40
4.08
4.76
5.44
6.12
LV_av AXIAL STRAIN (e)
E-03

Fig. E-40 E92M

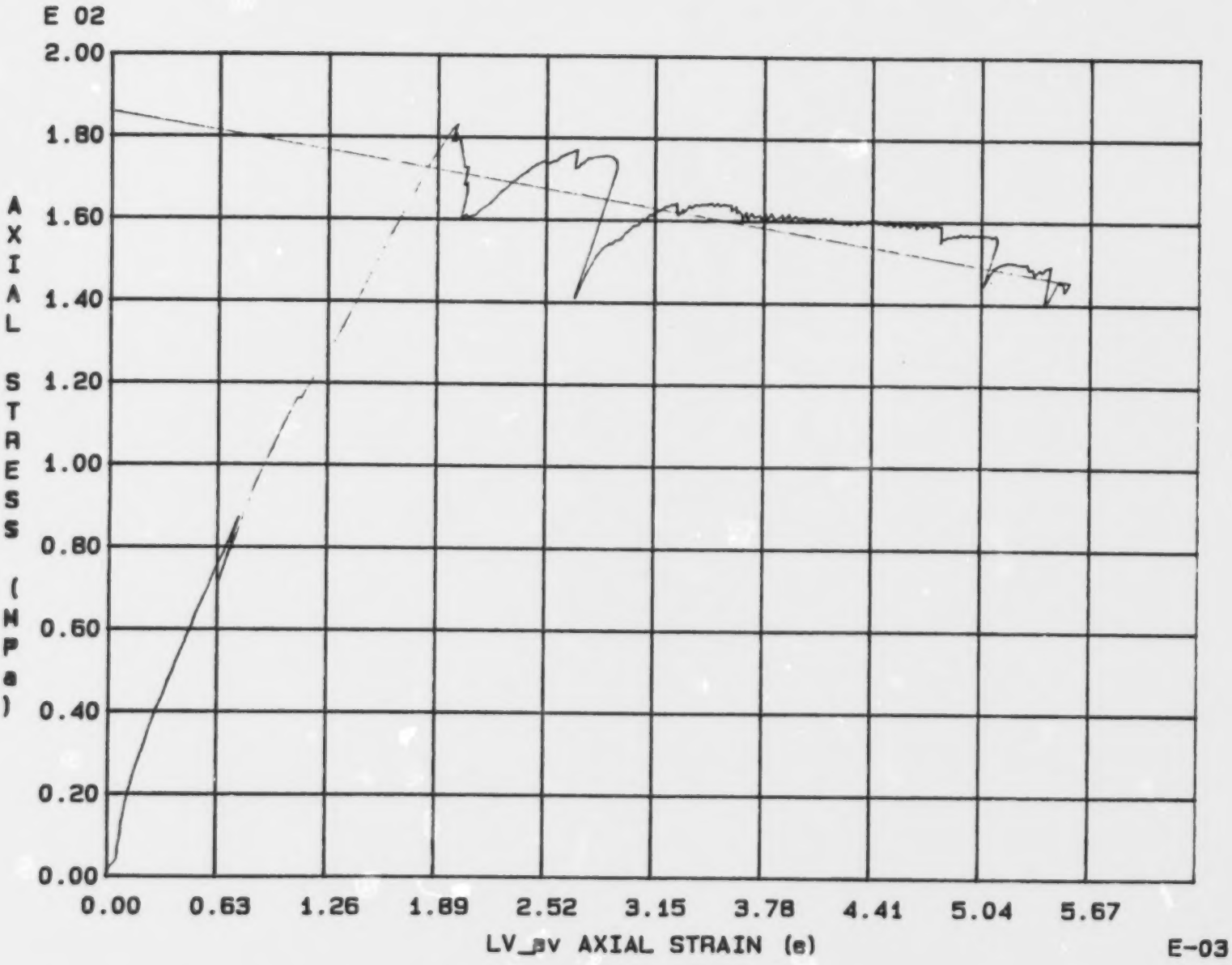

E 02
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
AXIAL STRESS (MPa)
0.00
0.63
1.26
1.89
2.52
3.15
3.78
4.41
5.04
5.67
LV_av AXIAL STRAIN (e)
E-03

Fig. E-41 E93M

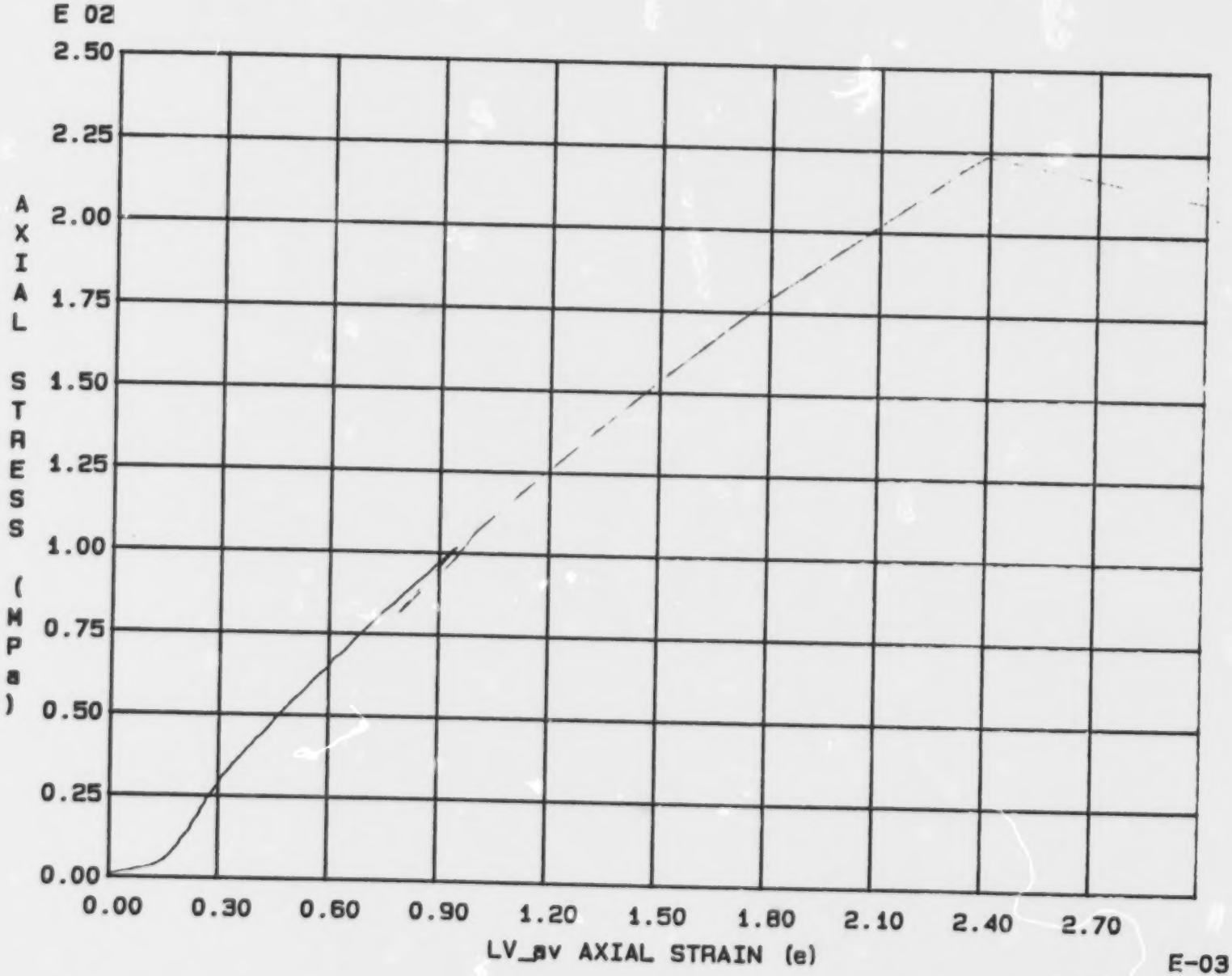

E 02
2.50
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
AXIAL STRESS (MPa)
0.00
0.30
0.60
0.90
1.20
1.50
1.80
2.10
2.40
2.70
LV_av AXIAL STRAIN (e)
E-03

Fig. E-42 E94M

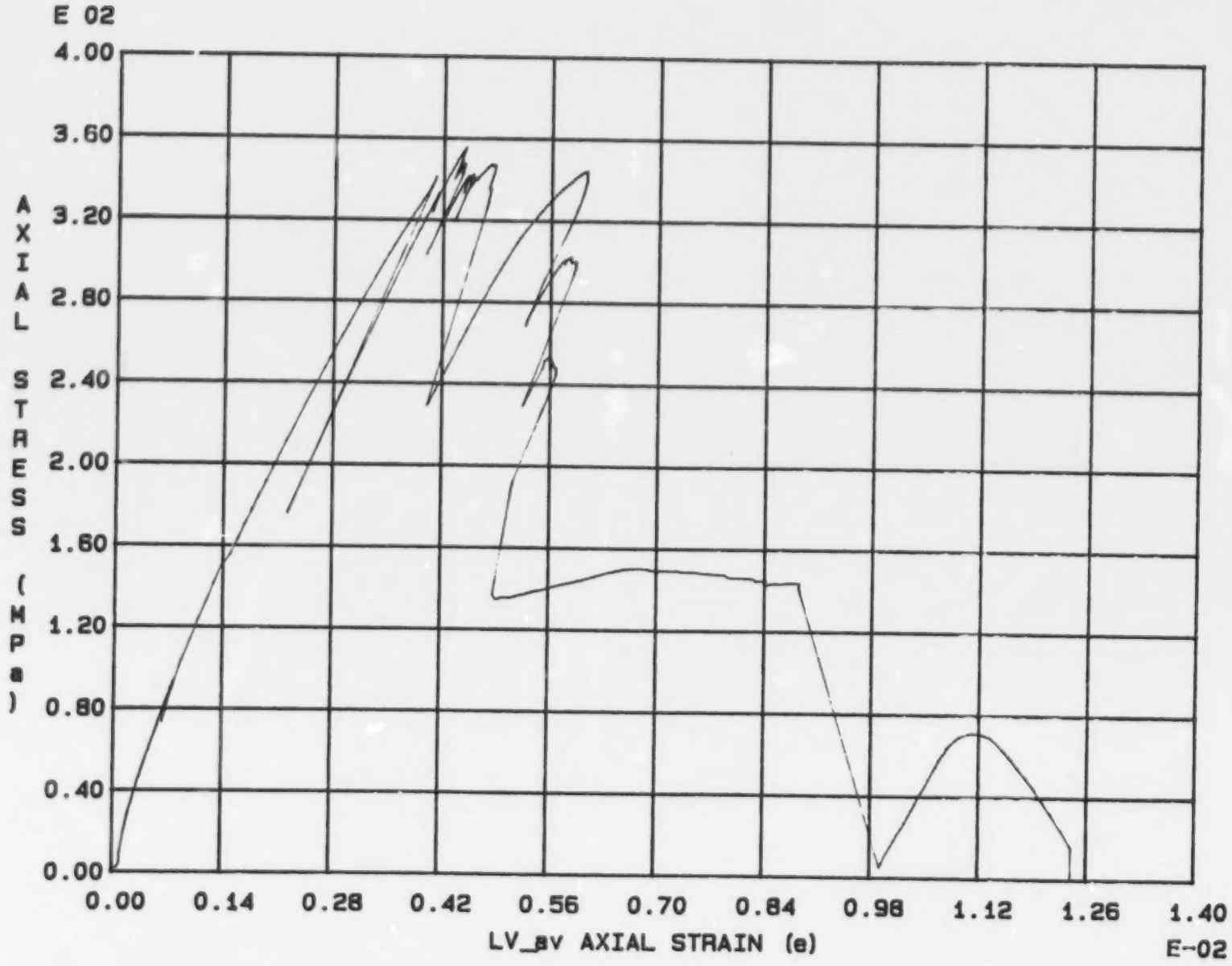

E 02
4.00
3.60
3.20
2.80
2.40
2.00
1.60
1.20
0.80
0.40
0.00
AXIAL STRESS (MPa)
0.00
0.14
0.28
0.42
0.56
0.70
0.84
0.98
1.12
1.26
1.40
LV_av AXIAL STRAIN (e)
E-02

Fig. E-43 E95M

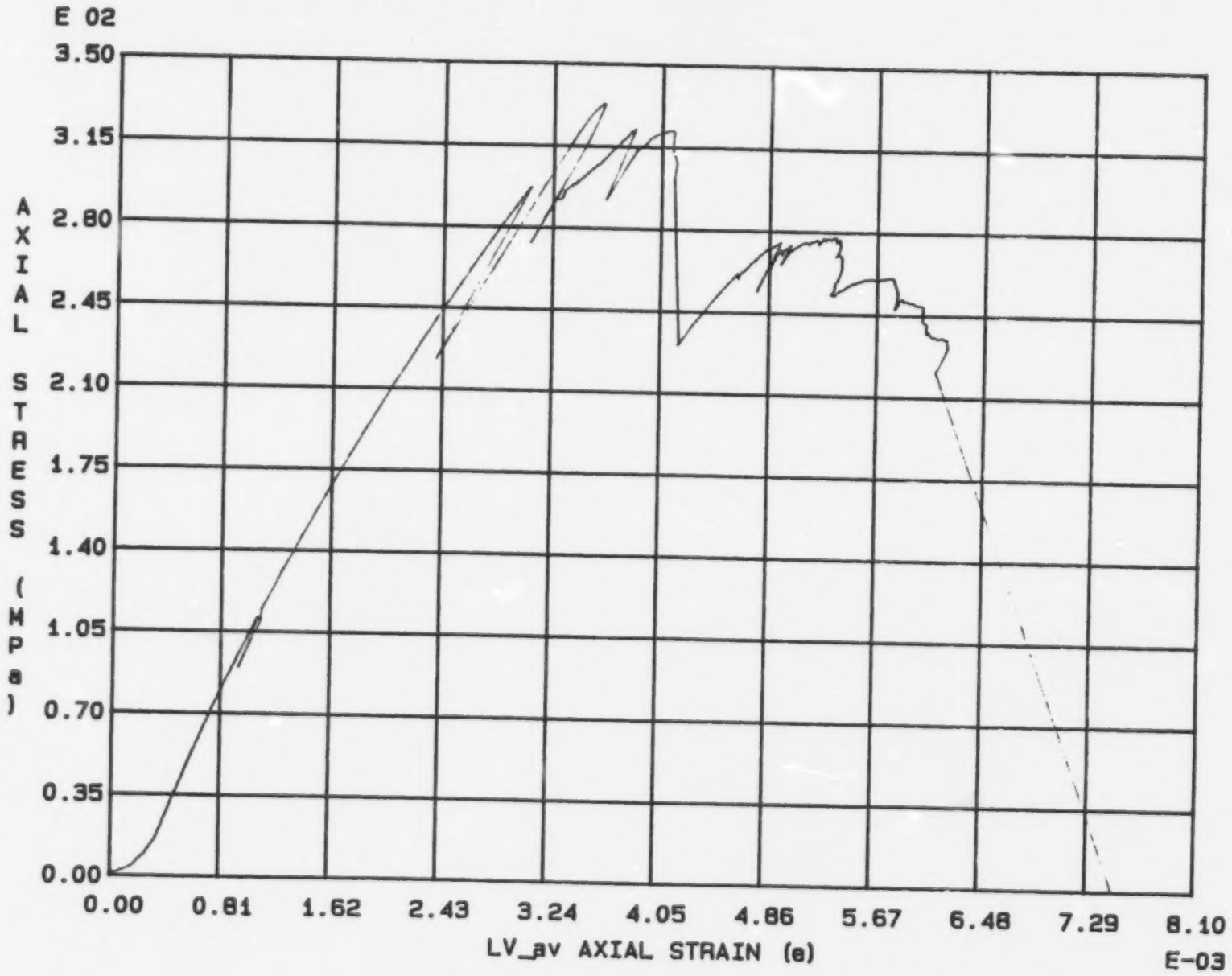

E 02
3.50
3.15
2.80
2.45
2.10
1.75
1.40
1.05
0.70
0.35
0.00
AXIAL STRESS (MPa)
0.00
0.81
1.62
2.43
3.24
4.05
4.86
5.67
6.48
7.29
8.10
E-03
LV_av AXIAL STRAIN (e)

Fig. E-44 E96M

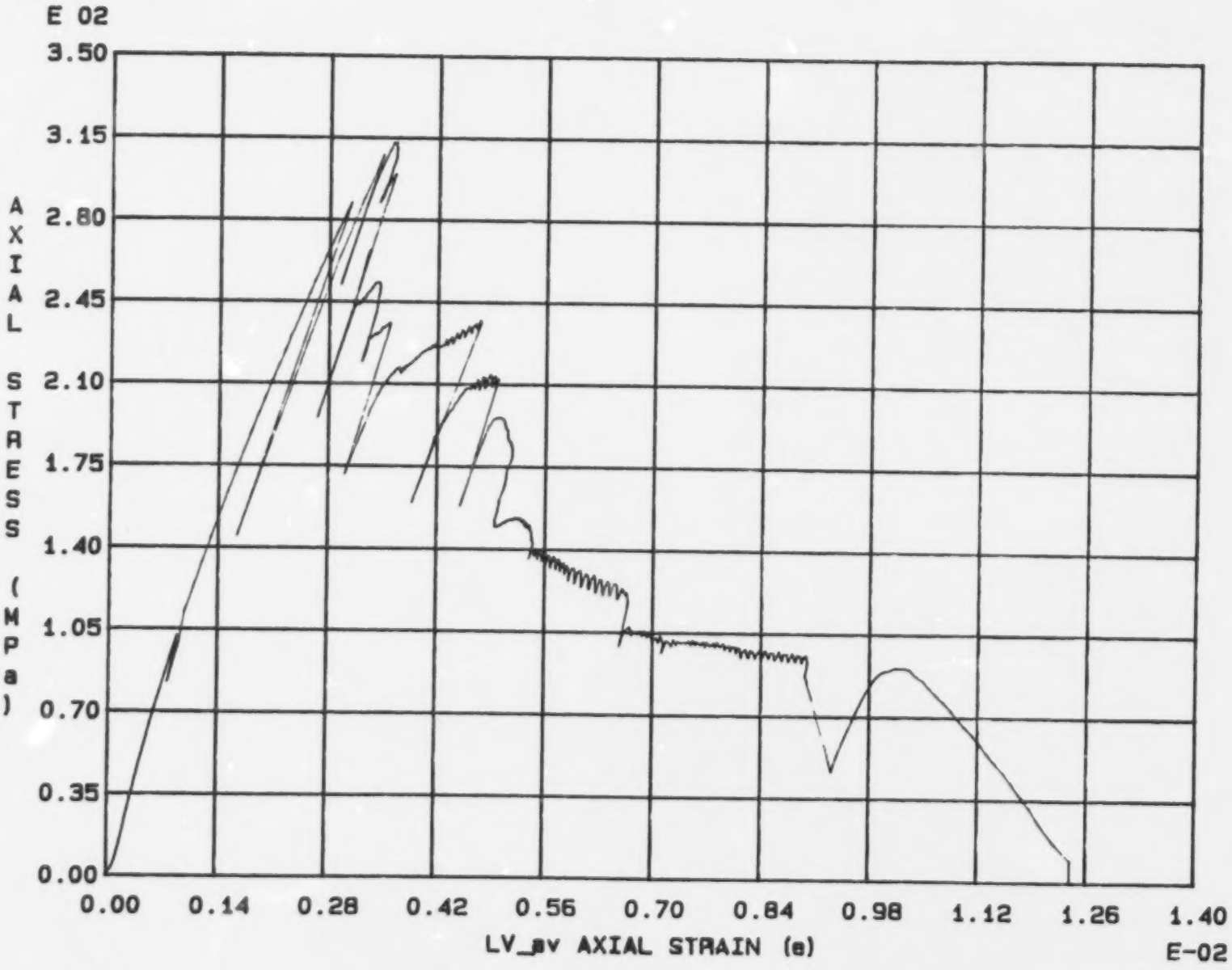

E 02
3.50
3.15
2.80
2.45
2.10
1.75
1.40
1.05
0.70
0.35
0.00
AXIAL STRESS (MPa)
0.00
0.14
0.28
0.42
0.56
0.70
0.84
0.98
1.12
1.26
1.40
LV_av AXIAL STRAIN (e)
E-02

Fig. E-45 E97M

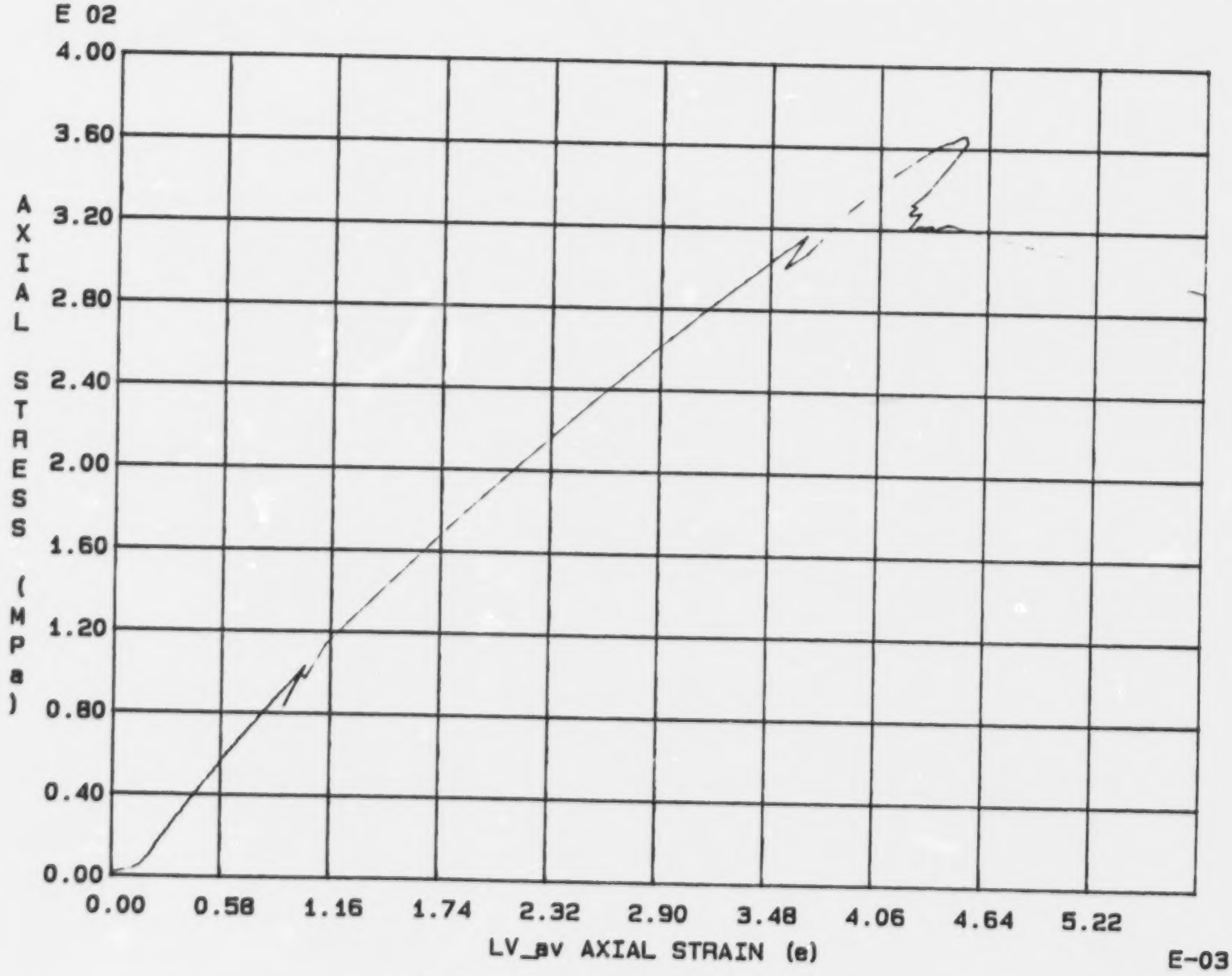

E 02
4.00
3.60
3.20
2.80
2.40
2.00
1.60
1.20
0.80
0.40
0.00
AXIAL STRESS (MPa)
0.00
0.58
1.16
1.74
2.32
2.90
3.48
4.06
4.64
5.22
LV_av AXIAL STRAIN (e)
E-03

Fig. E-46 E98M

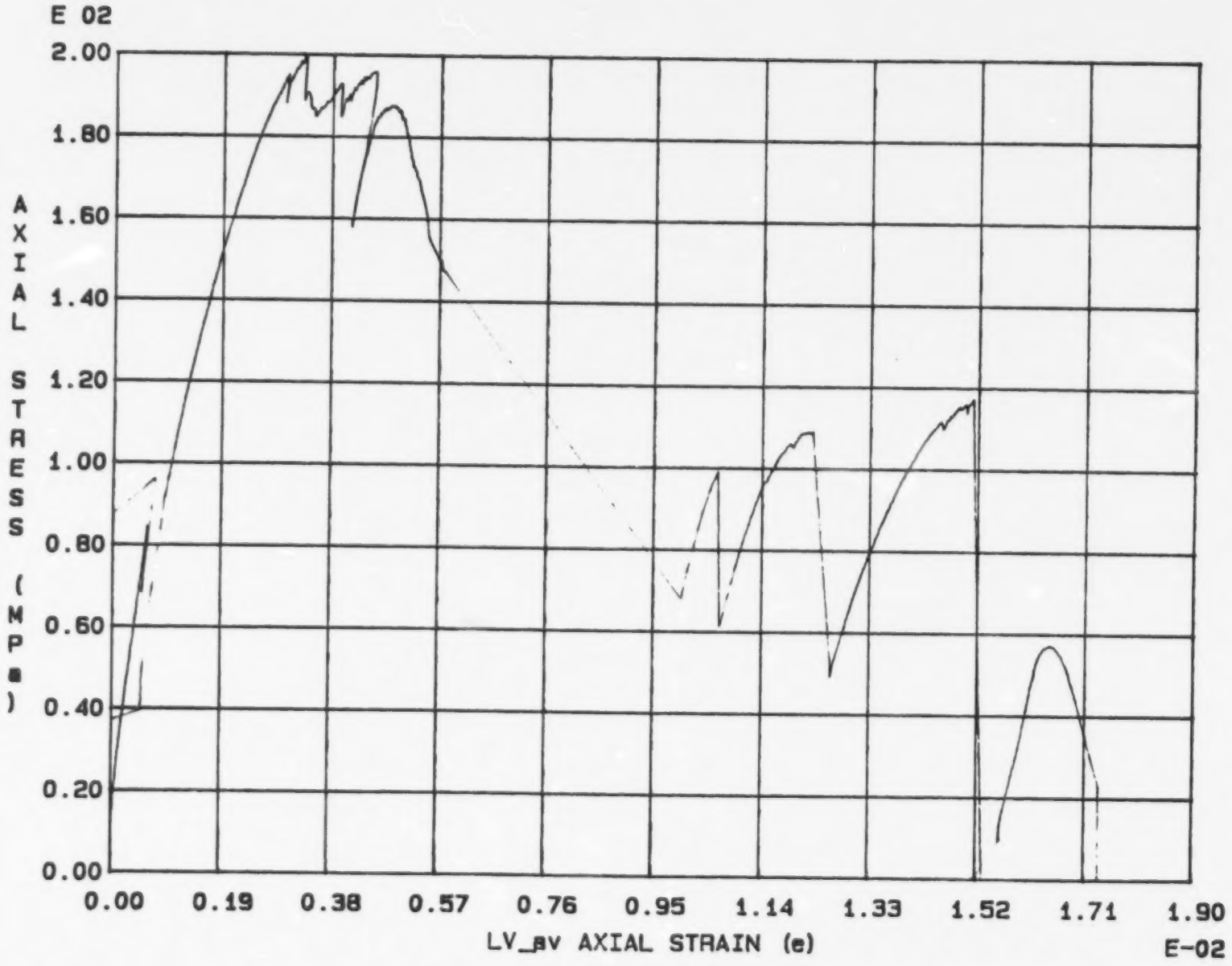

E 02
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
AXIAL STRESS (MPa)
0.00
0.19
0.38
0.57
0.76
0.95
1.14
1.33
1.52
1.71
1.90
LV_av AXIAL STRAIN (e)
E-02

Fig. E-47 E99M

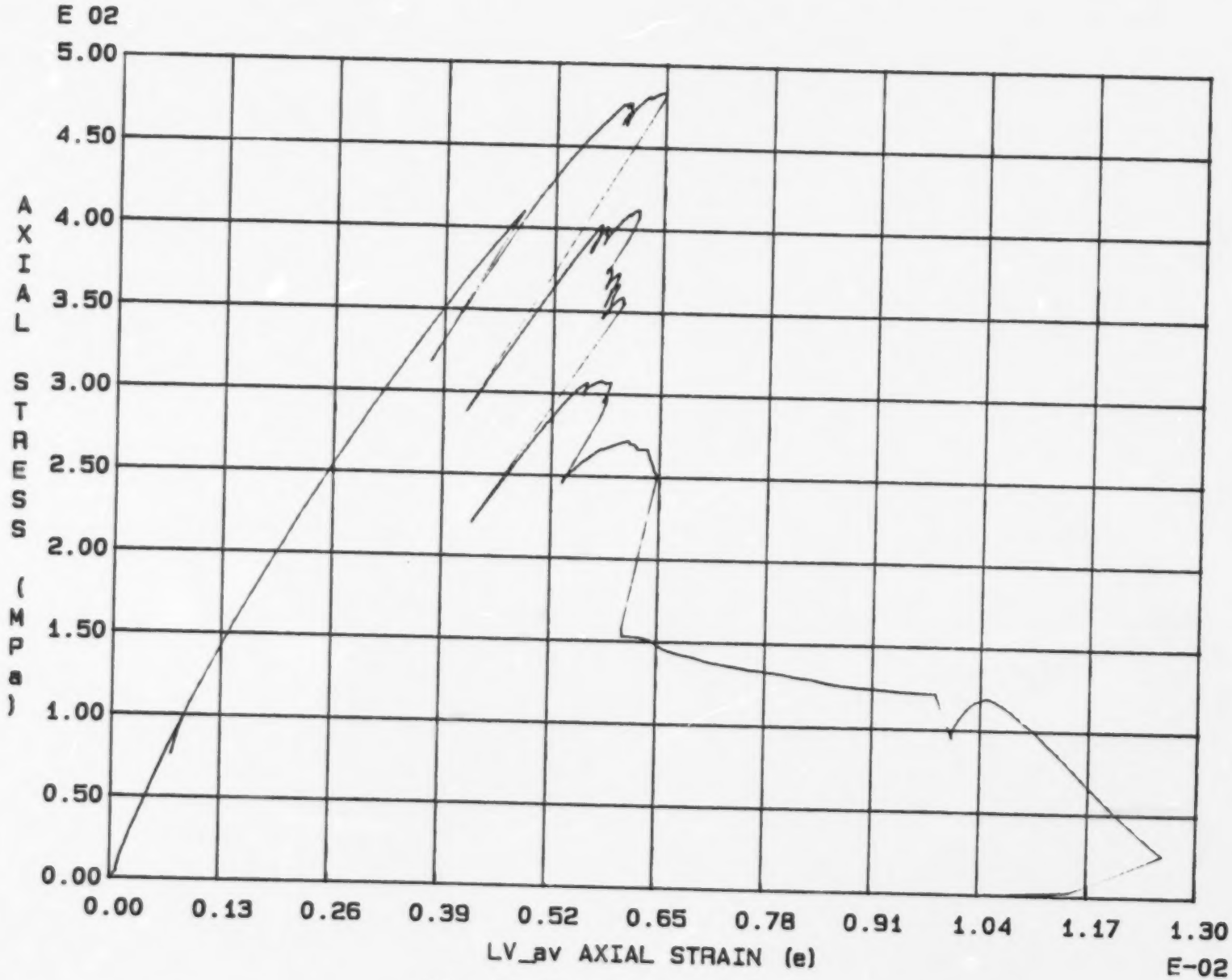


Fig. E-48 E100M

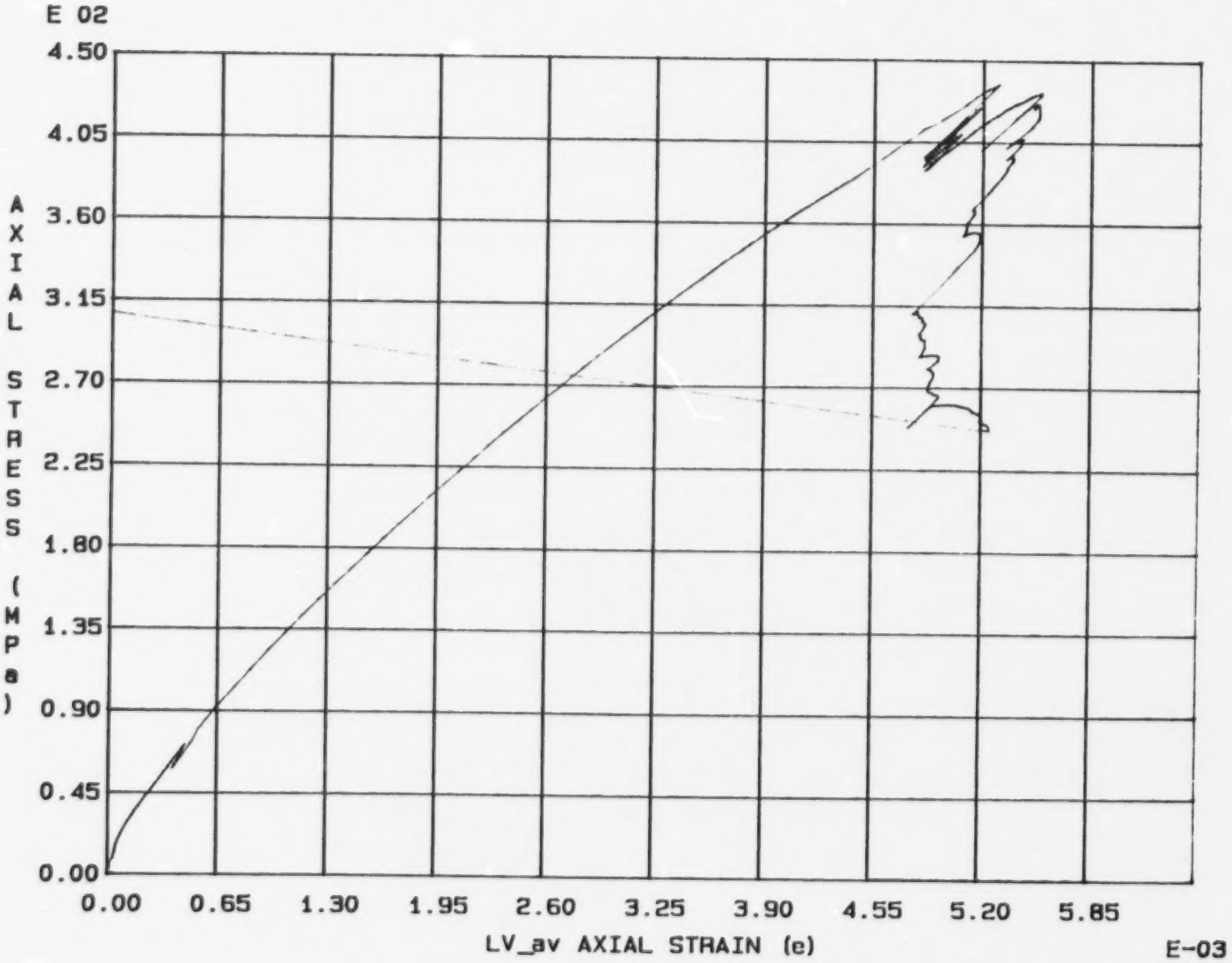


Fig. E-49 E101M

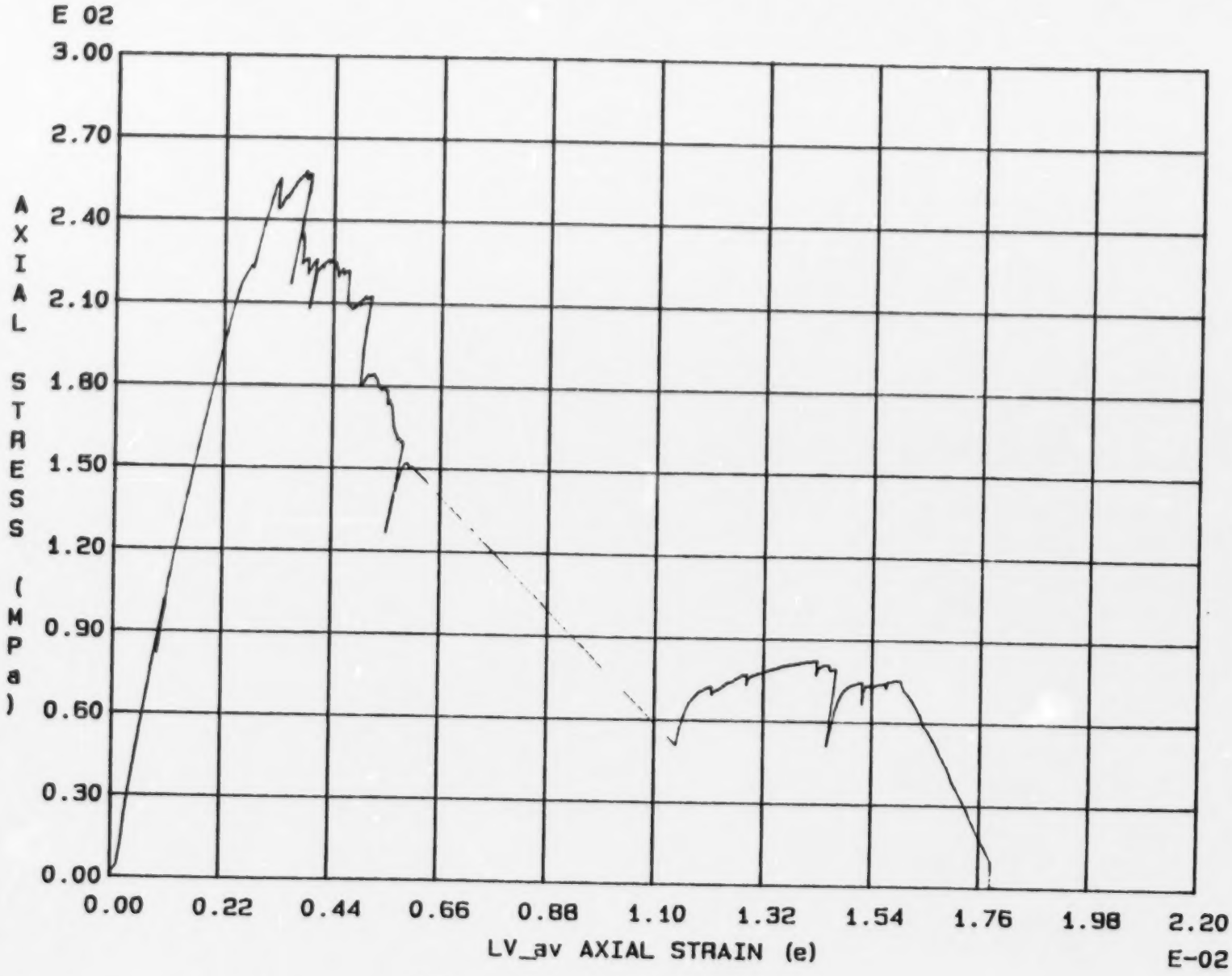


Fig. E-50 E102M

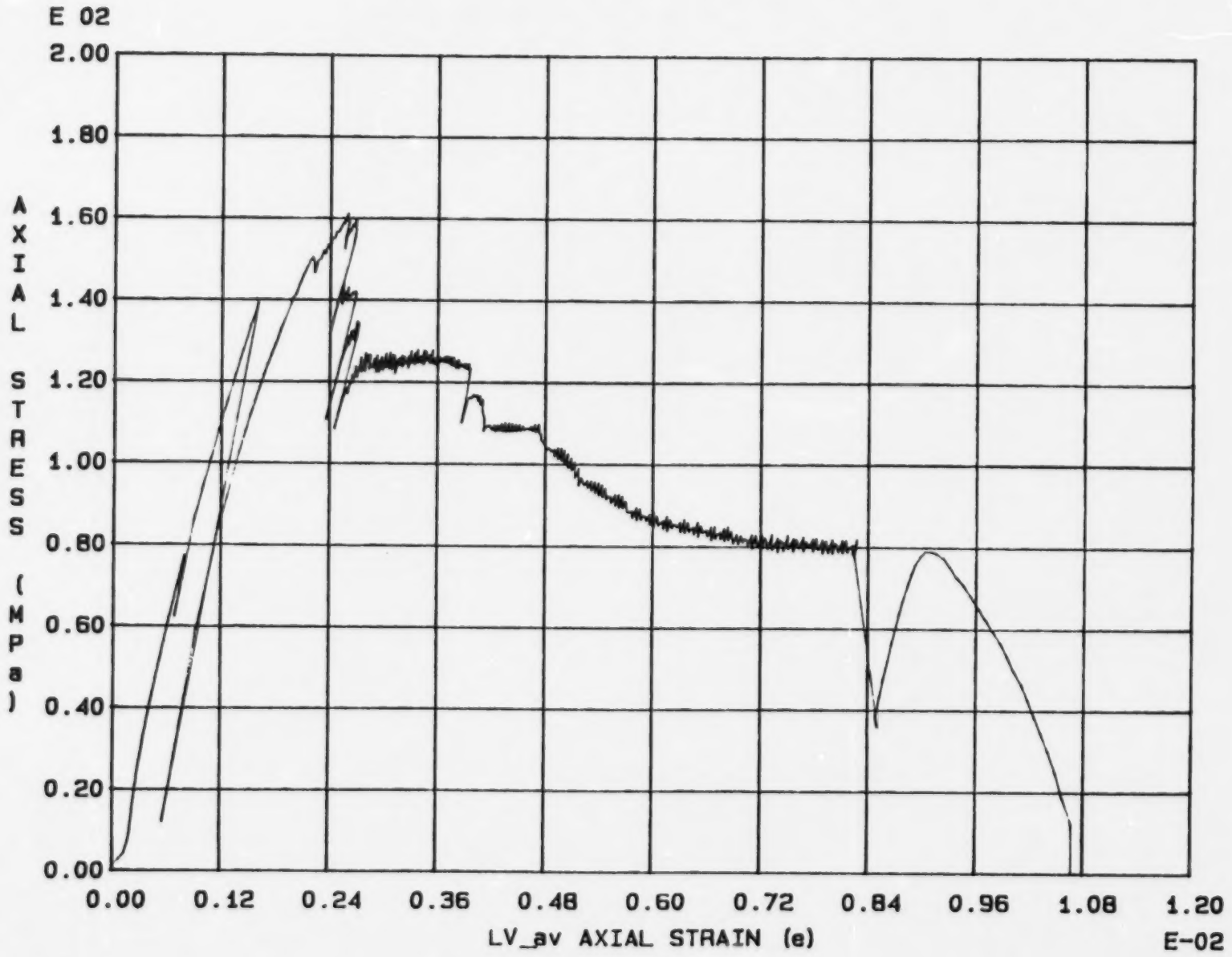


Fig. E-51 E119M

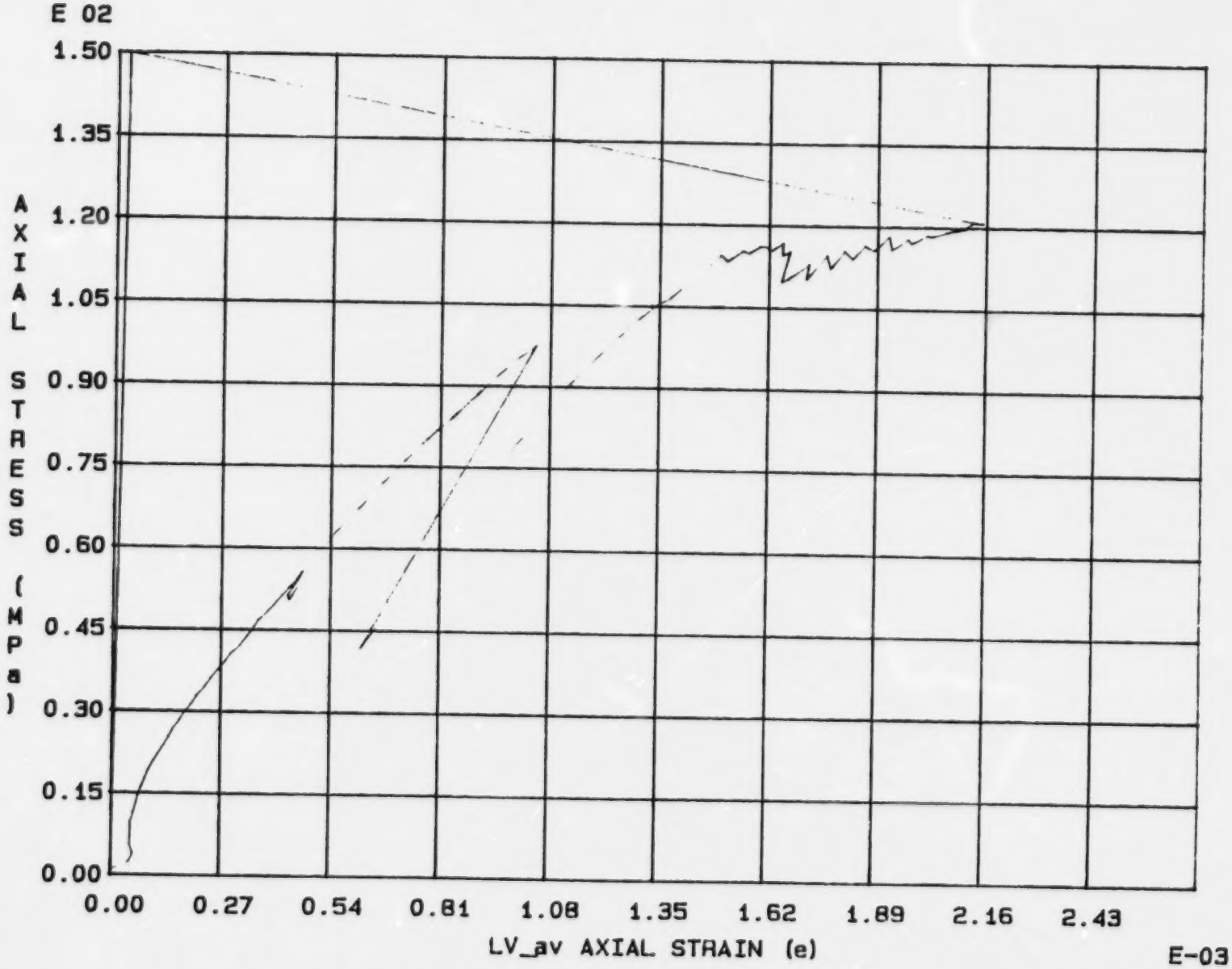


Fig. E-52 E120M

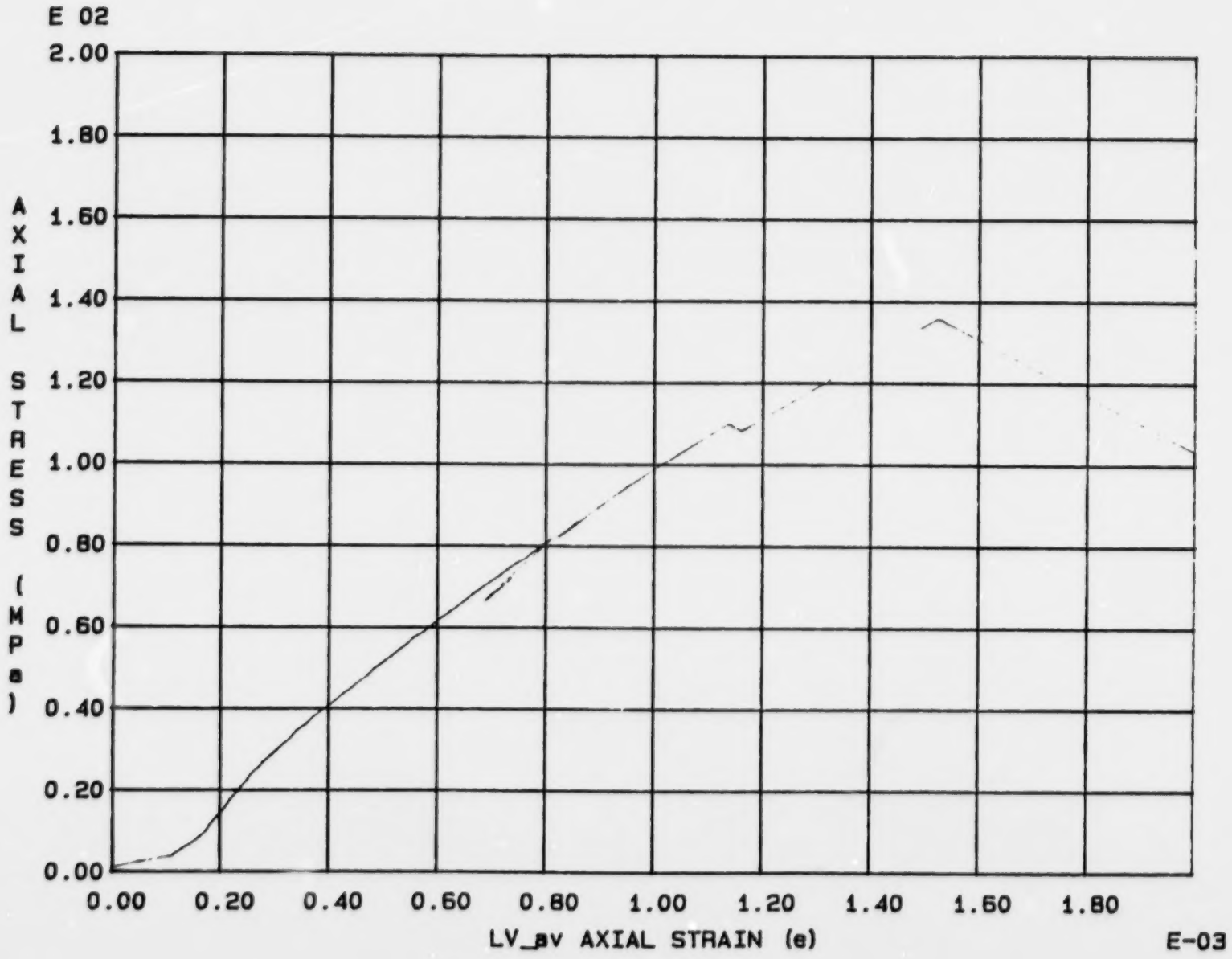


Fig. E-53 E121M

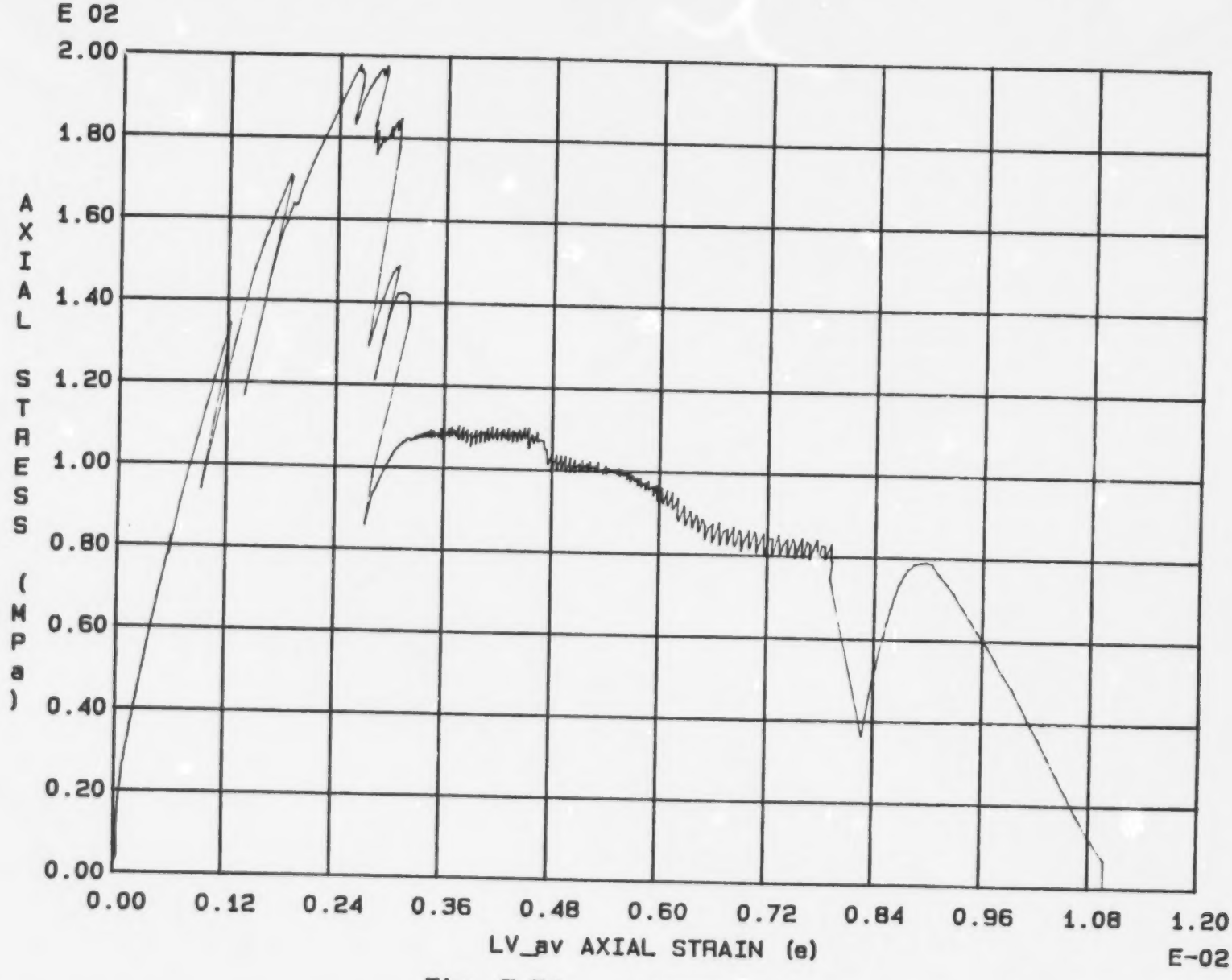


Fig. E-54 E122M

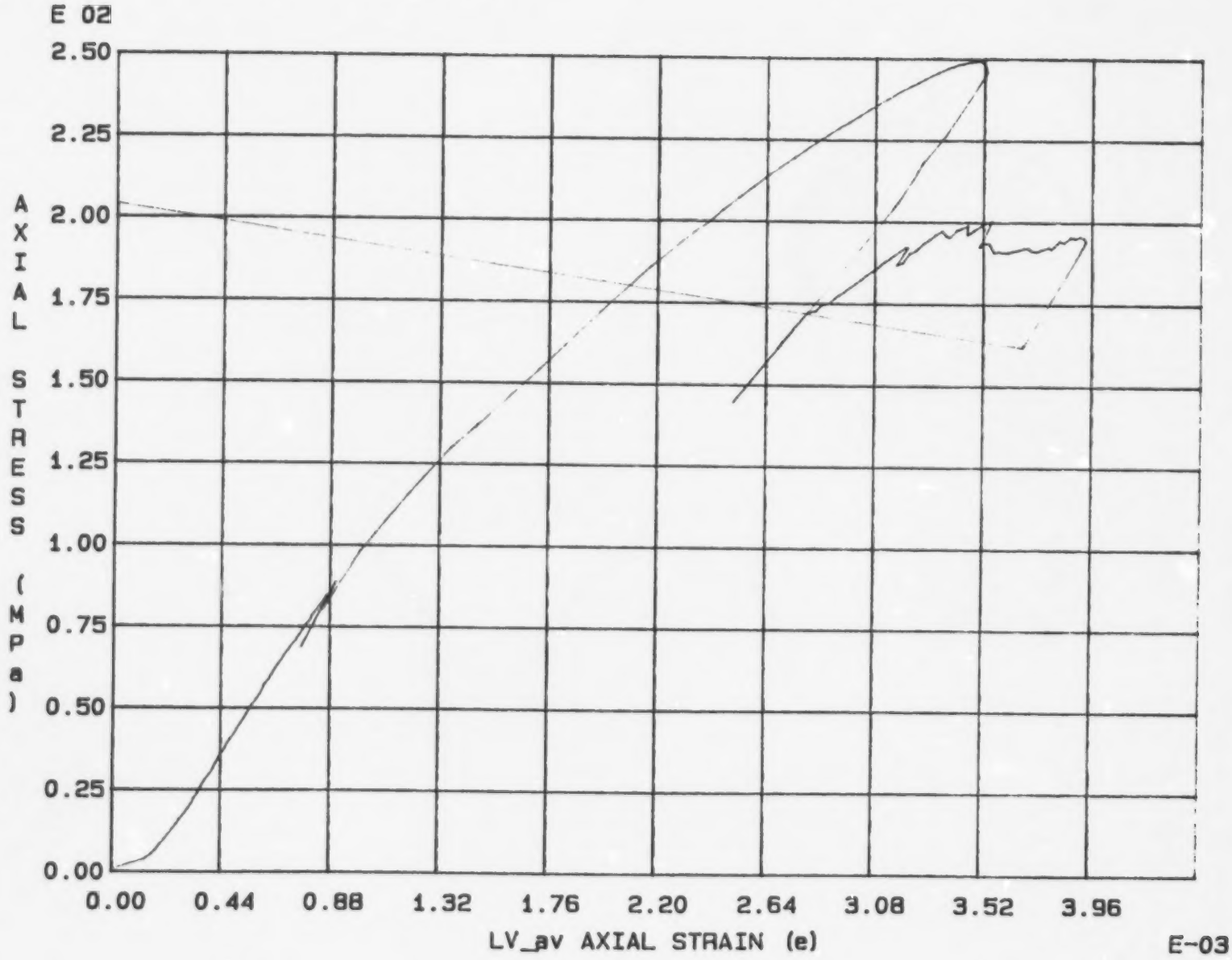


Fig. E-55 E123M

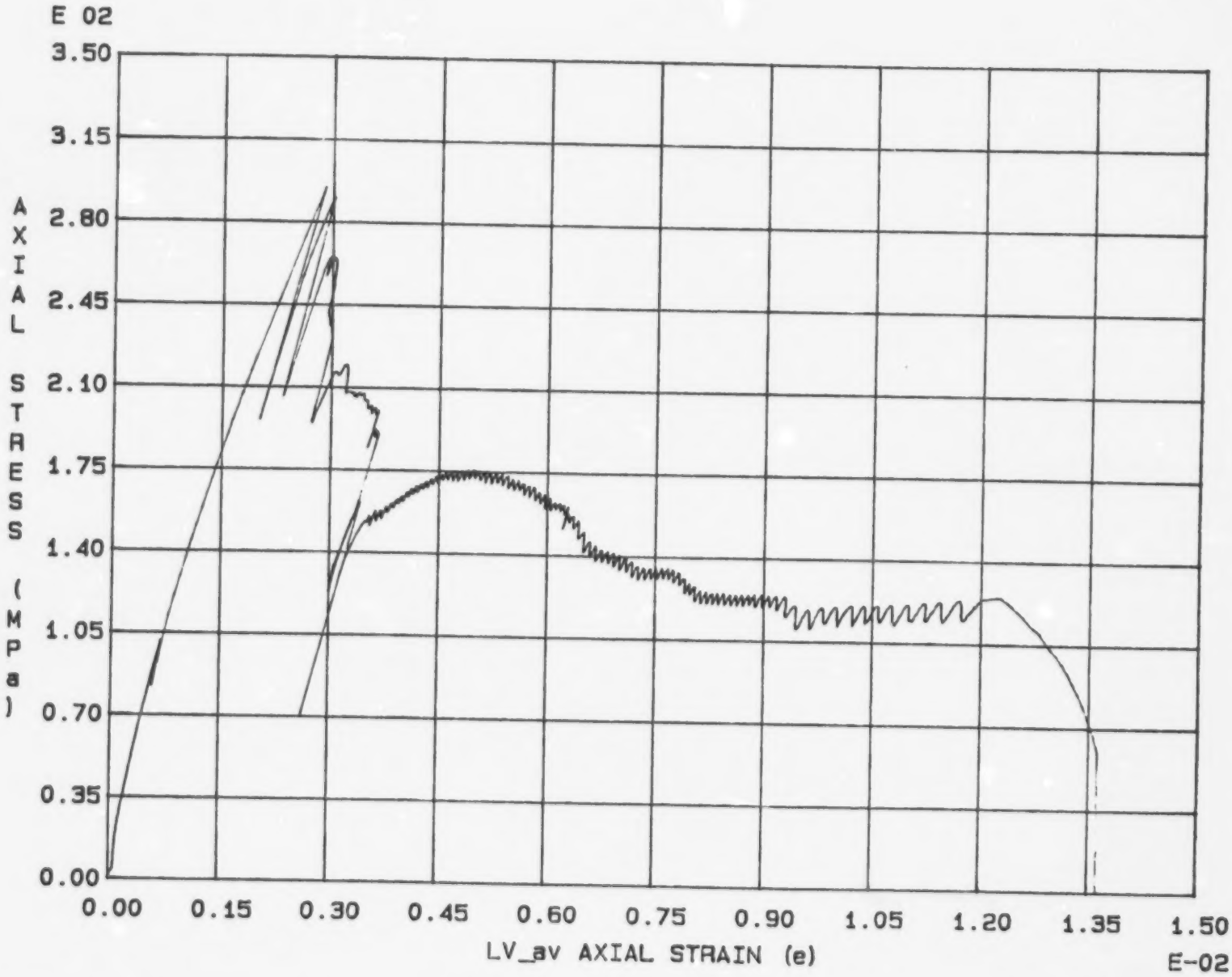


Fig. E-56 E124M

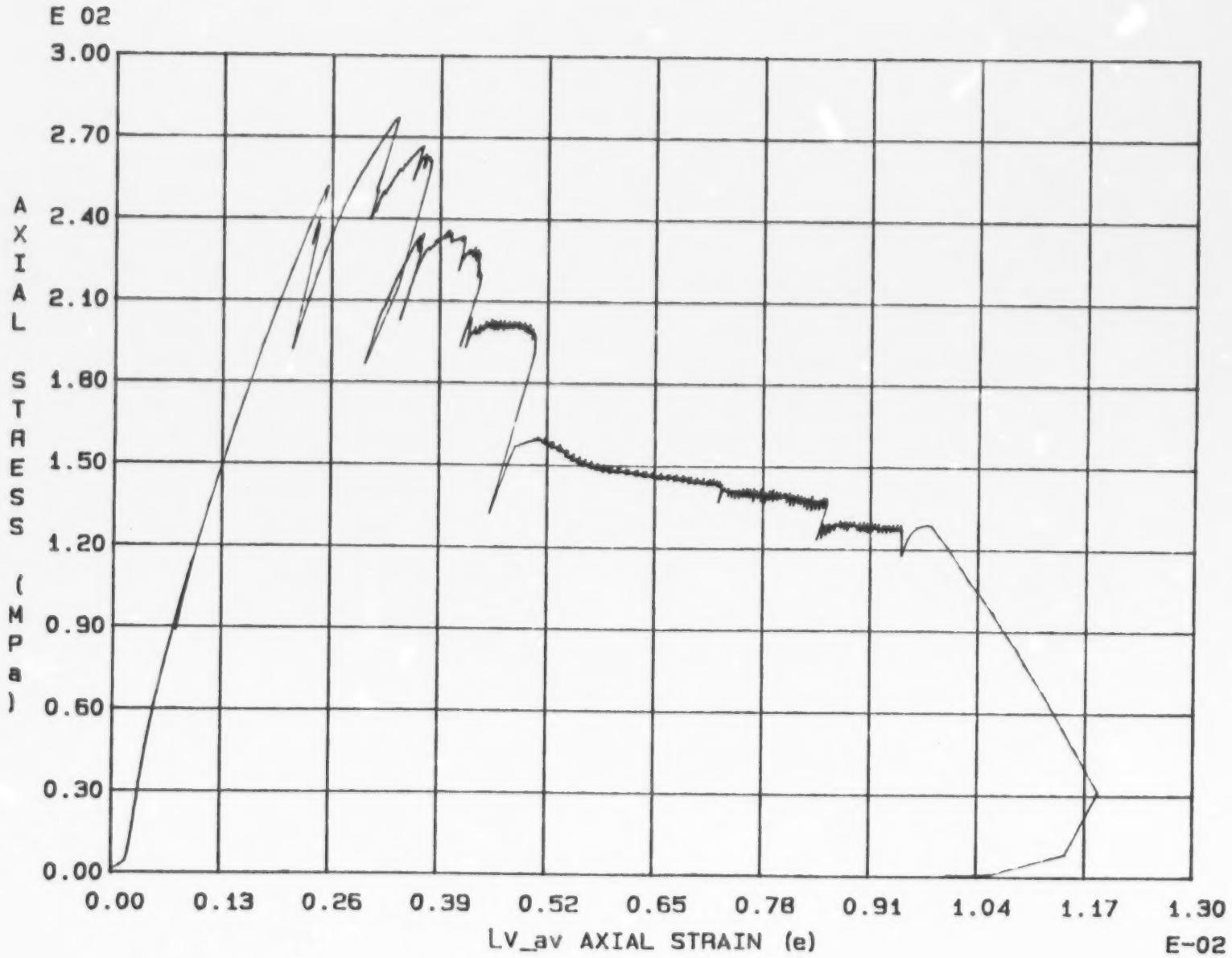


Fig. E-57 E125M

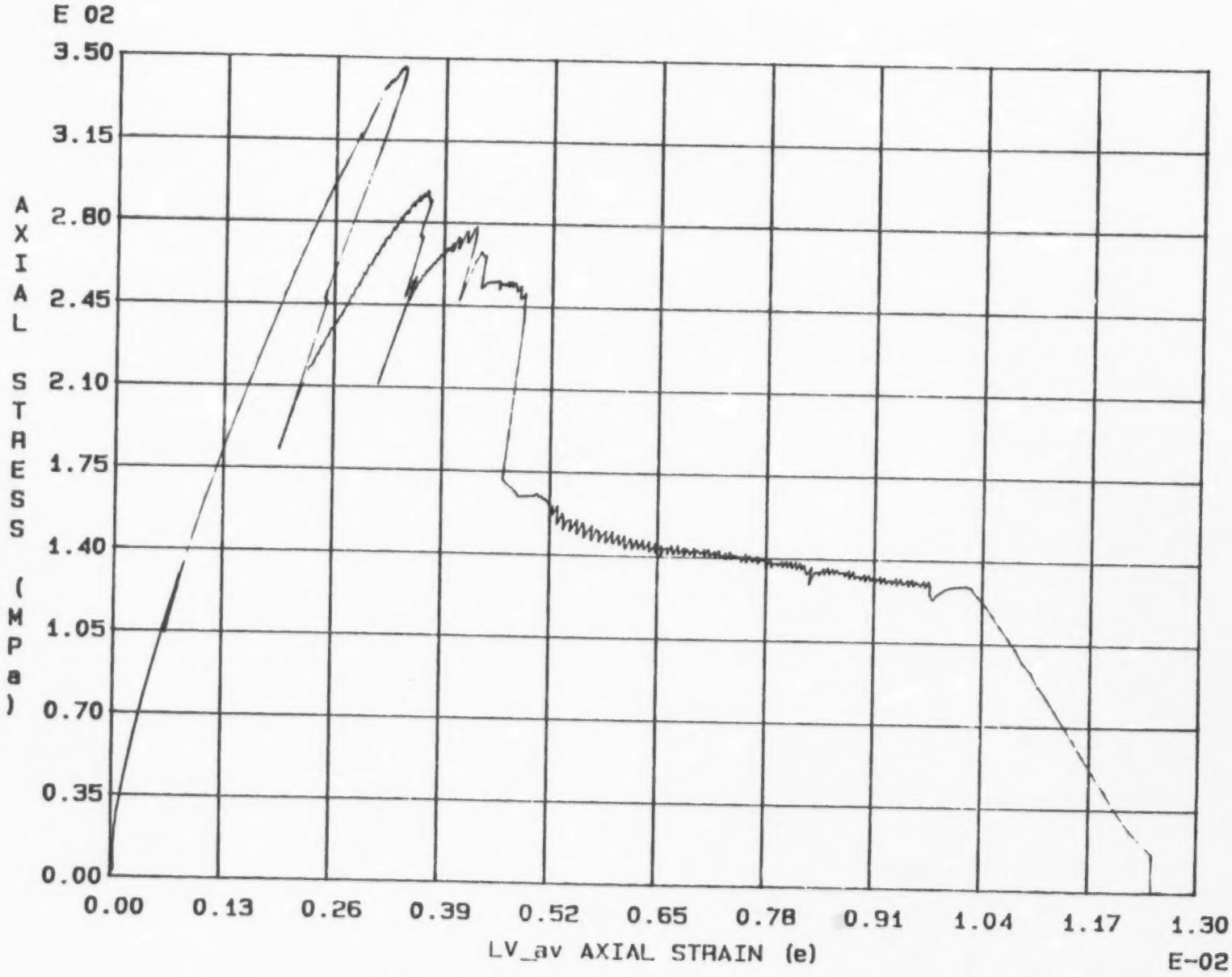


Fig. E-58 E126M

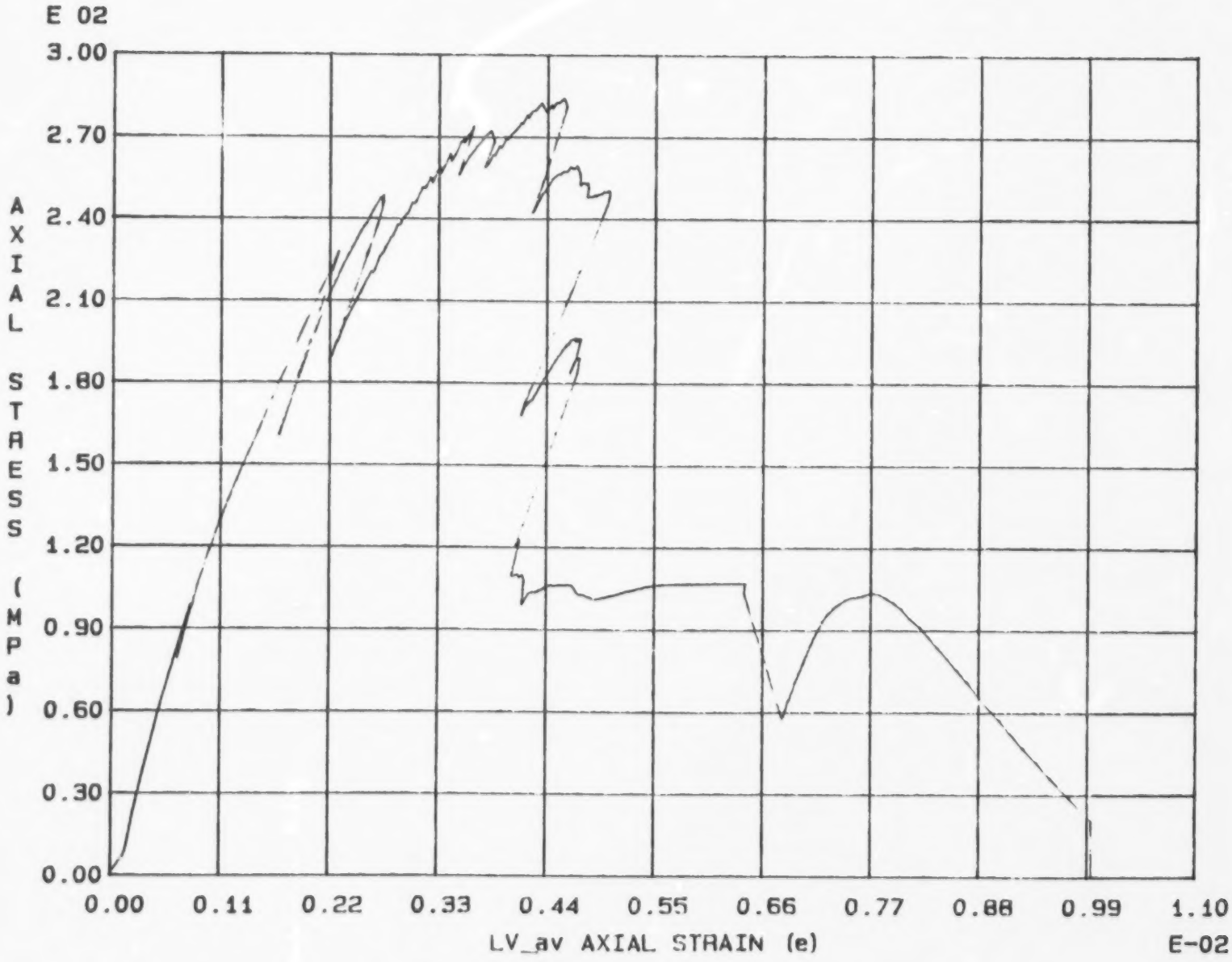


Fig. E-59 E127M

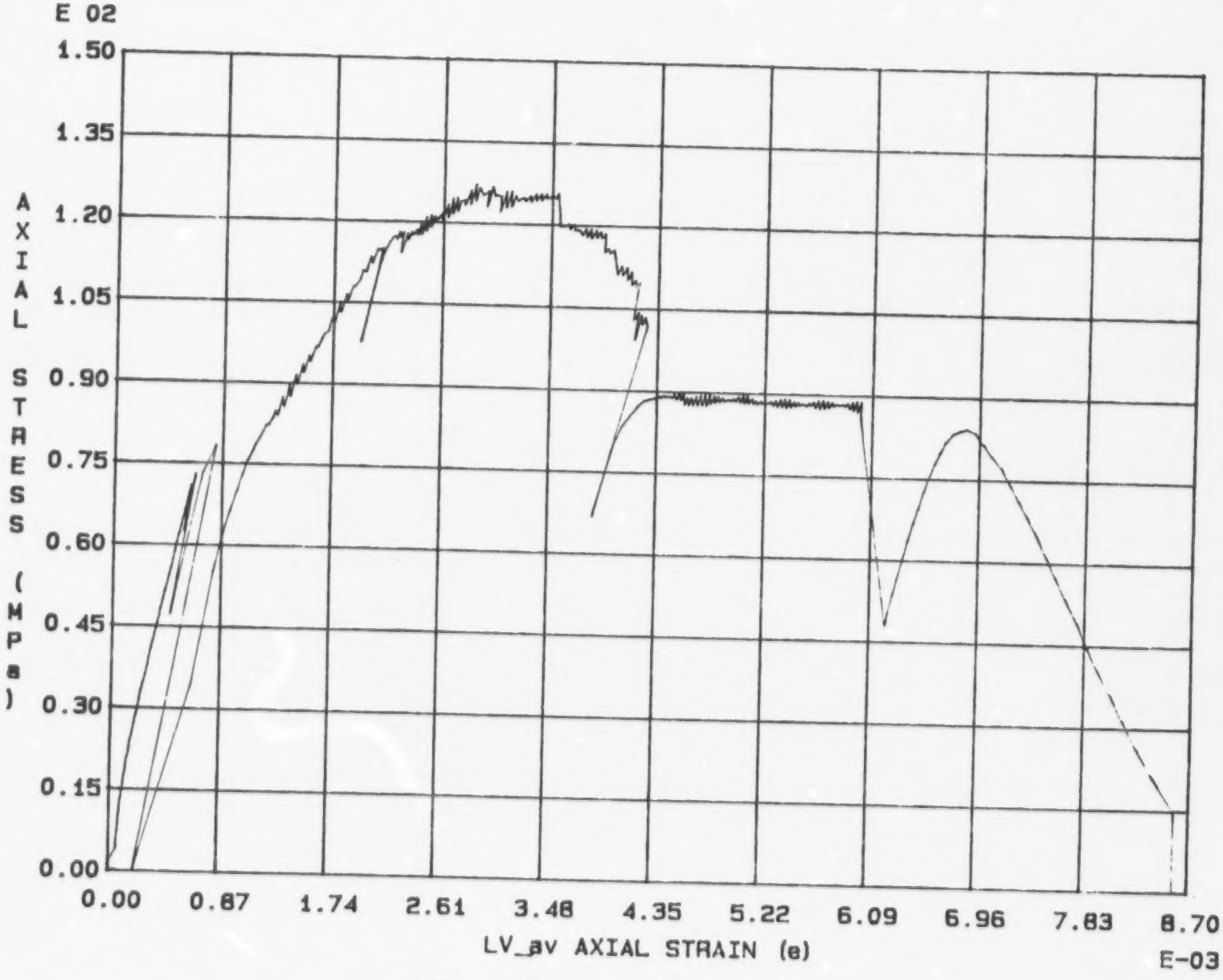


Fig. E-80 E128M

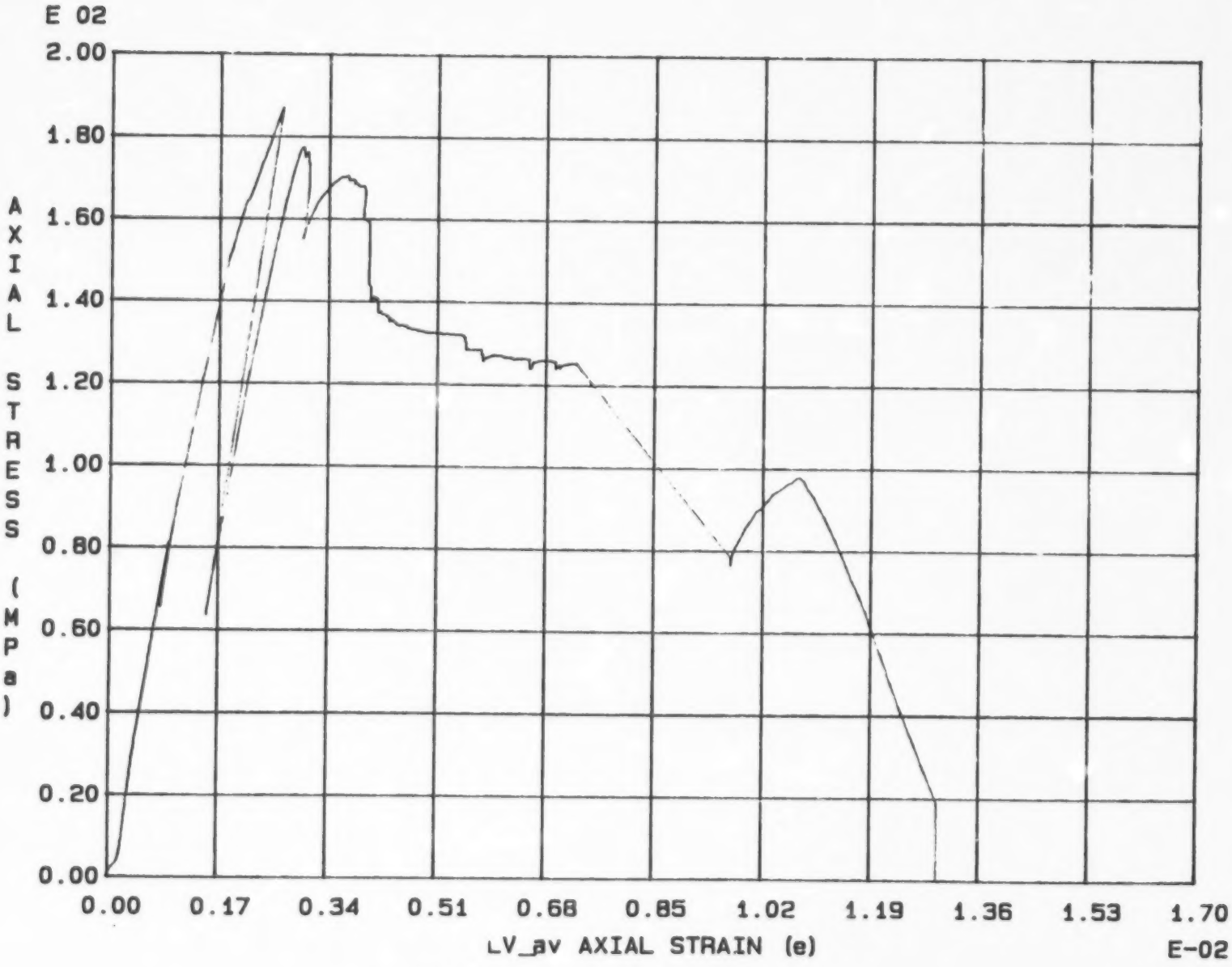


Fig. E-61 E129M

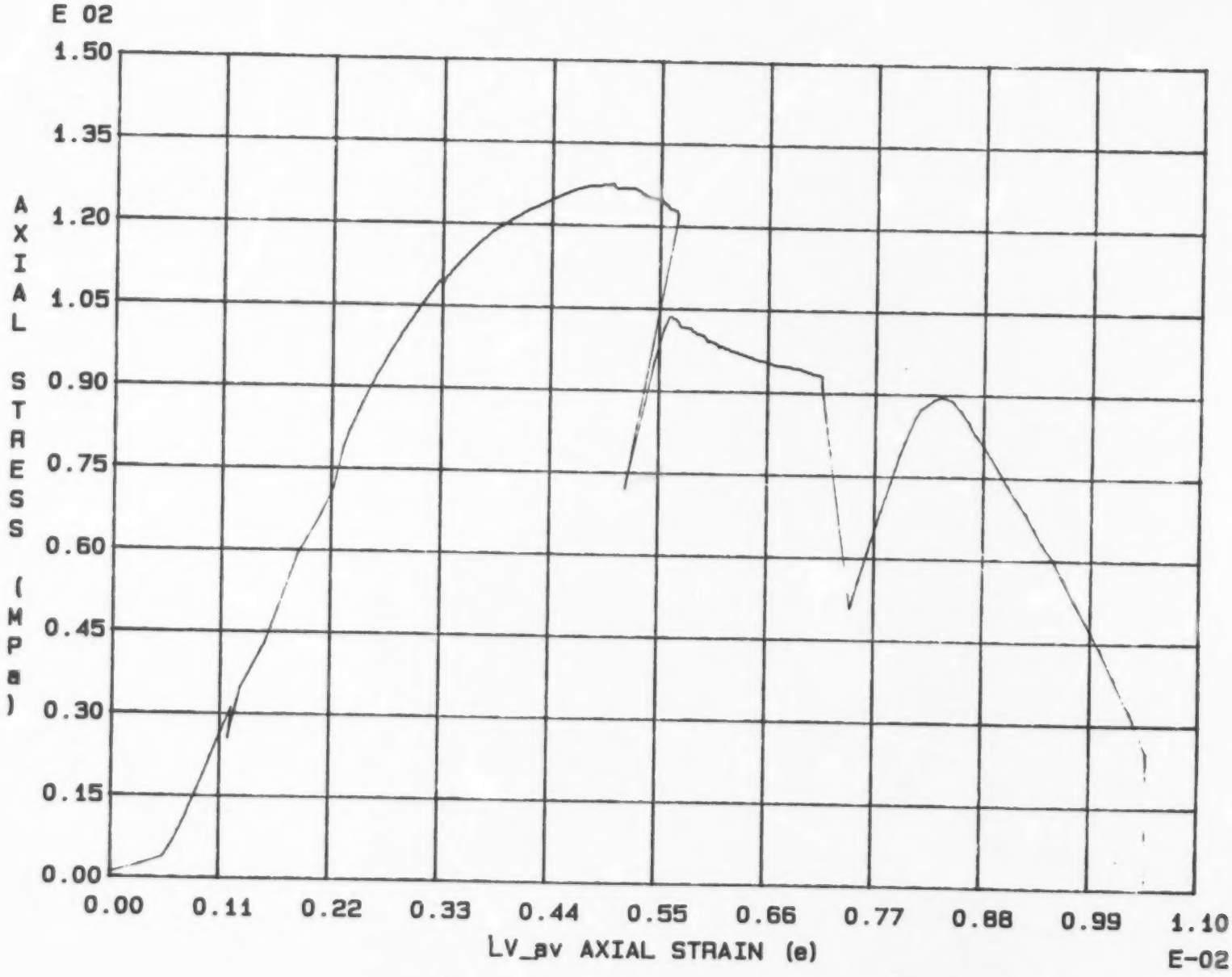


Fig. E-62 E130M

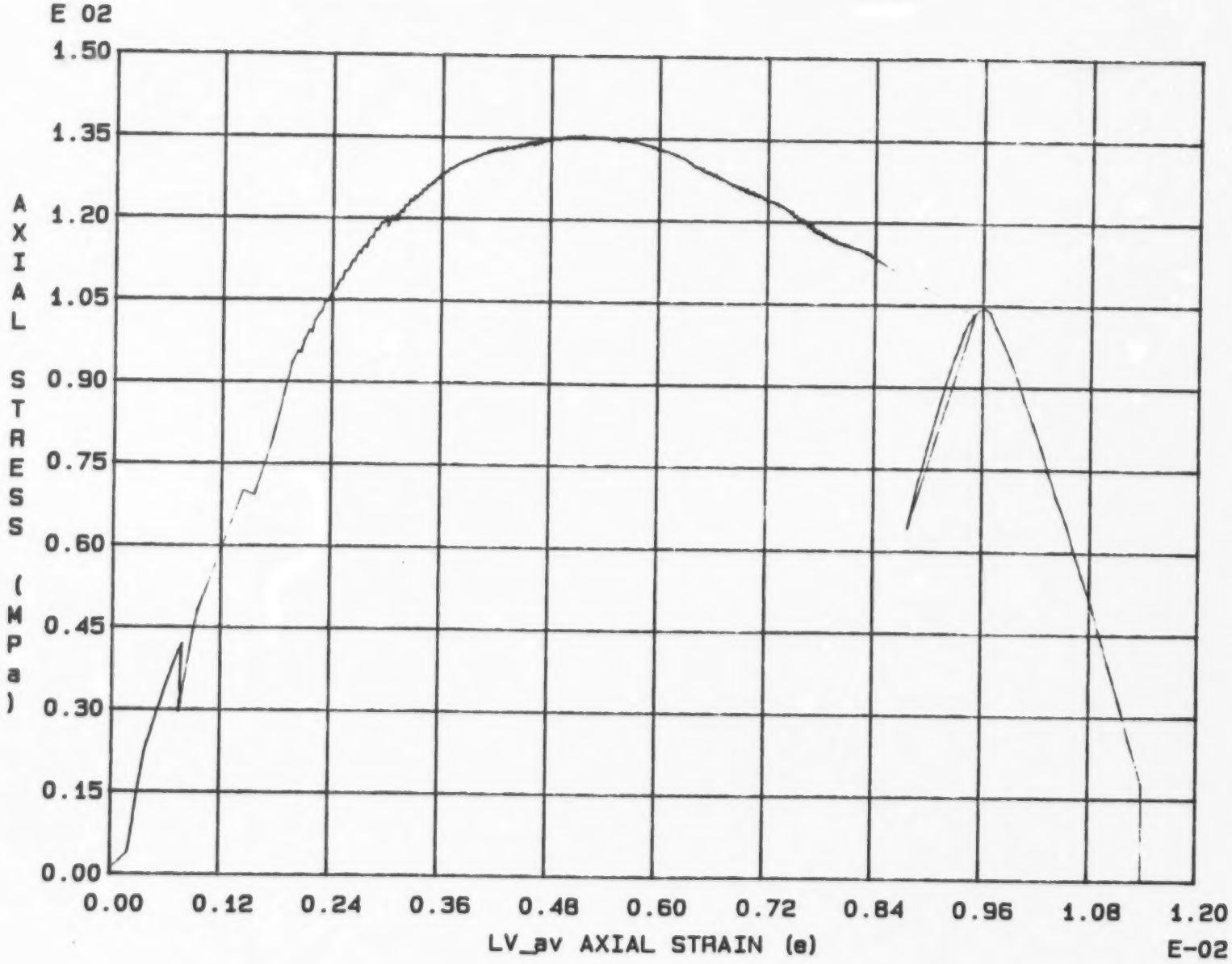


Fig. E-63 E131M

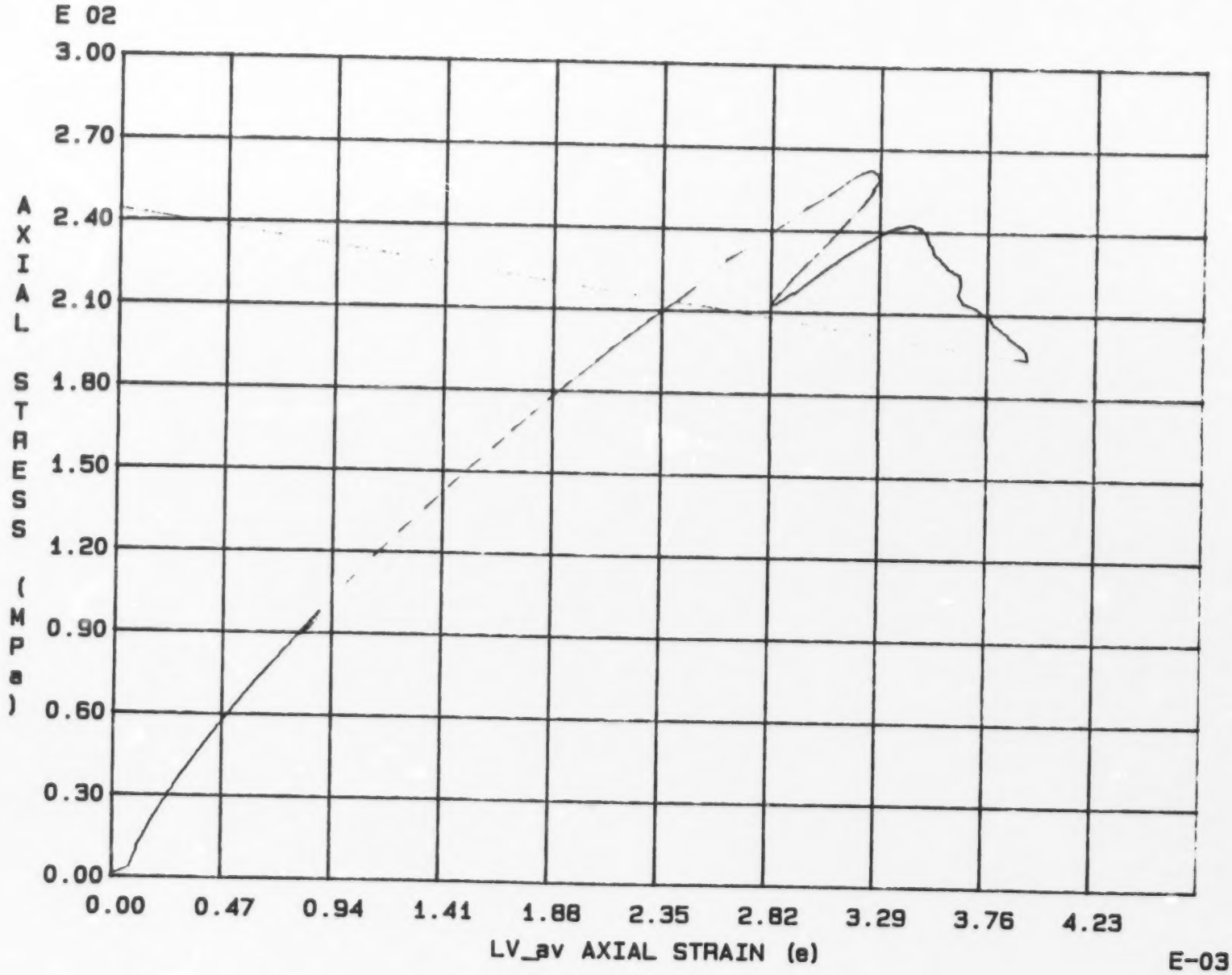


Fig. E-64 E132M

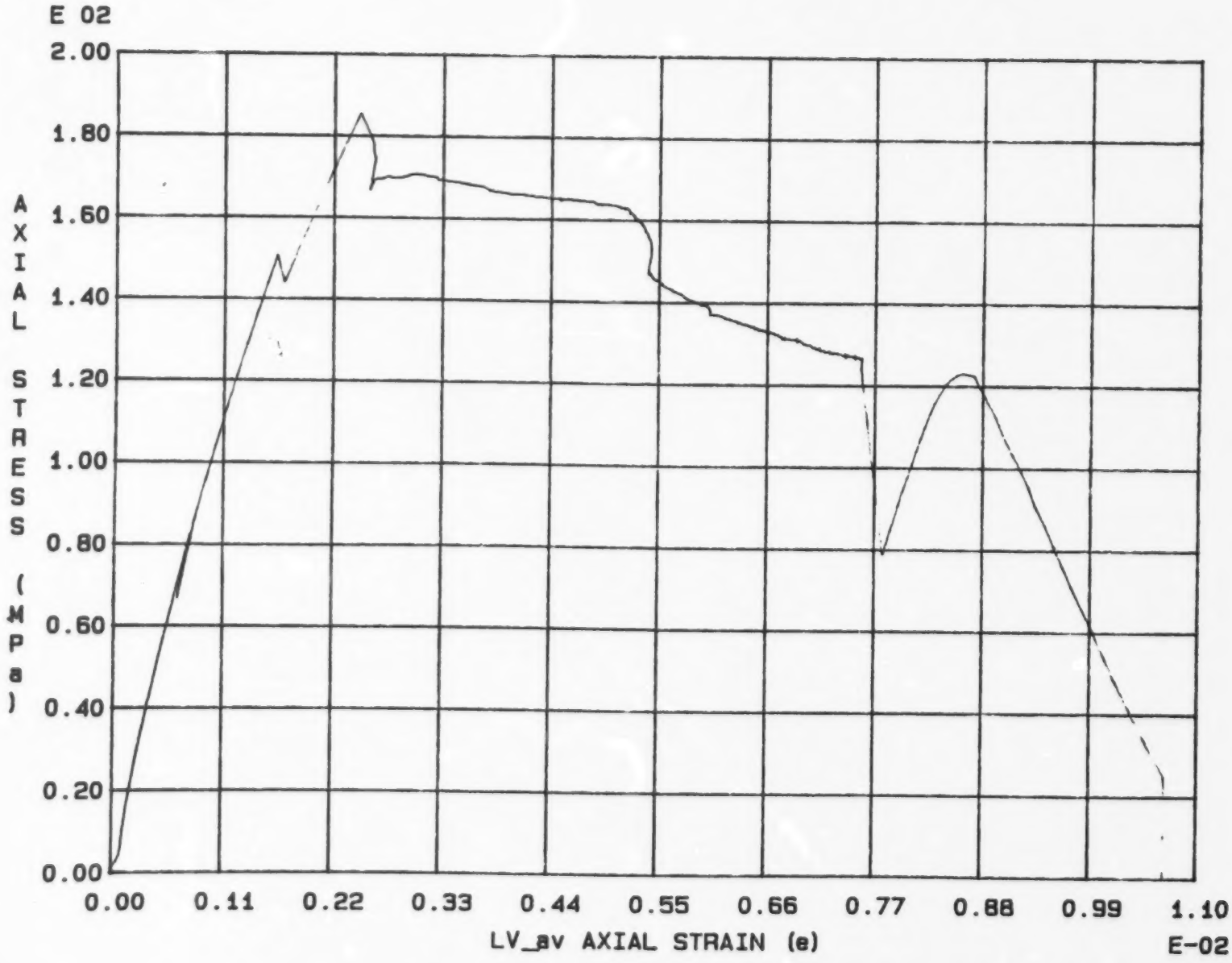


Fig. E-65 E133M

APPENDIX F

STRESS-STRAIN CURVES OF TRIAXIAL TESTS USING CIRCUMFERENTIAL EXTENSOMETER

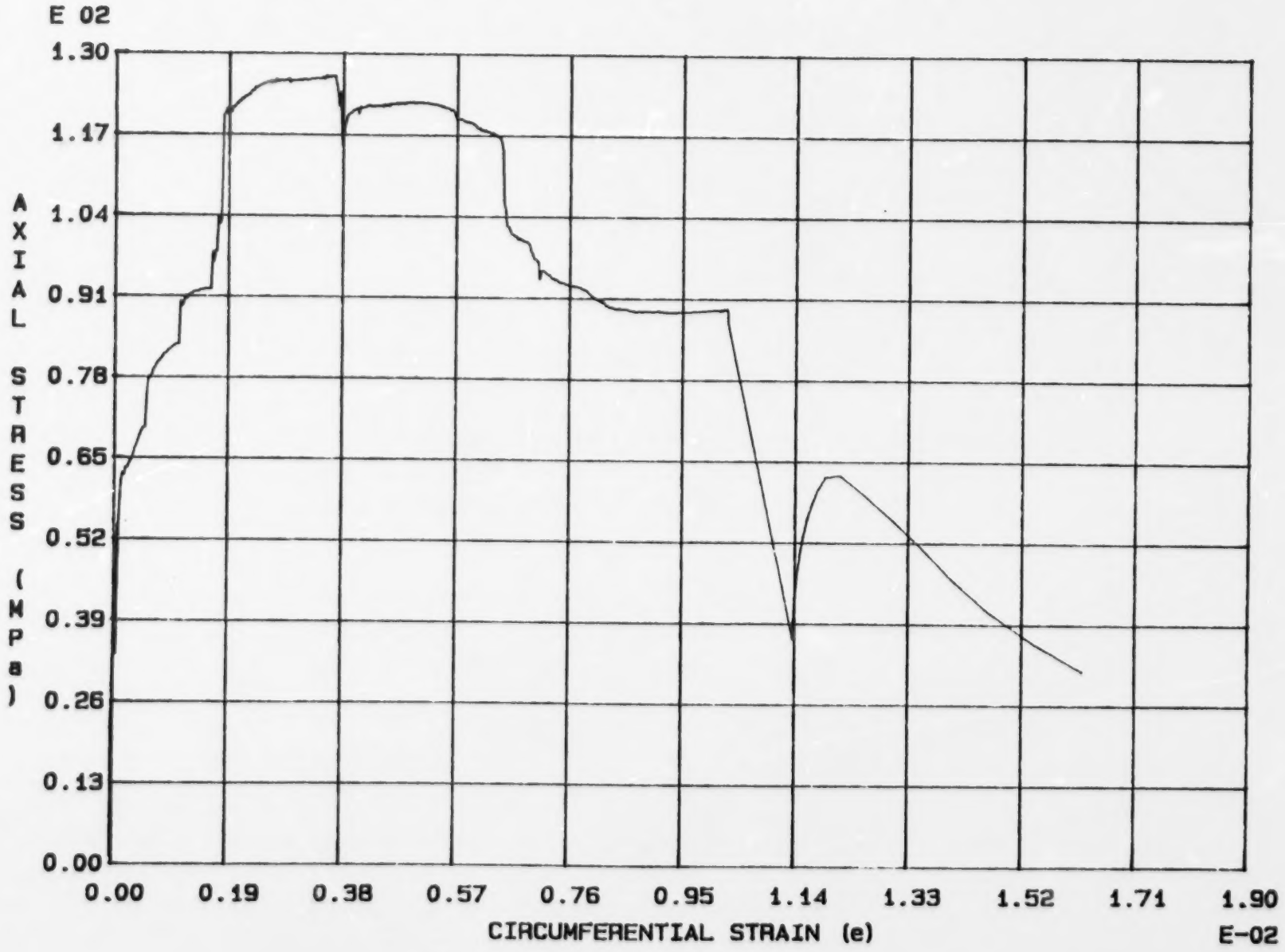

E 02
1.30
1.17
1.04
0.91
0.78
0.65
0.52
0.39
0.26
0.13
0.00
AXIAL STRESS (MPa)
0.00
0.19
0.38
0.57
0.76
0.95
1.14
1.33
1.52
1.71
1.90
CIRCUMFERENTIAL STRAIN (e)
E-02

Fig. F-1 E2T

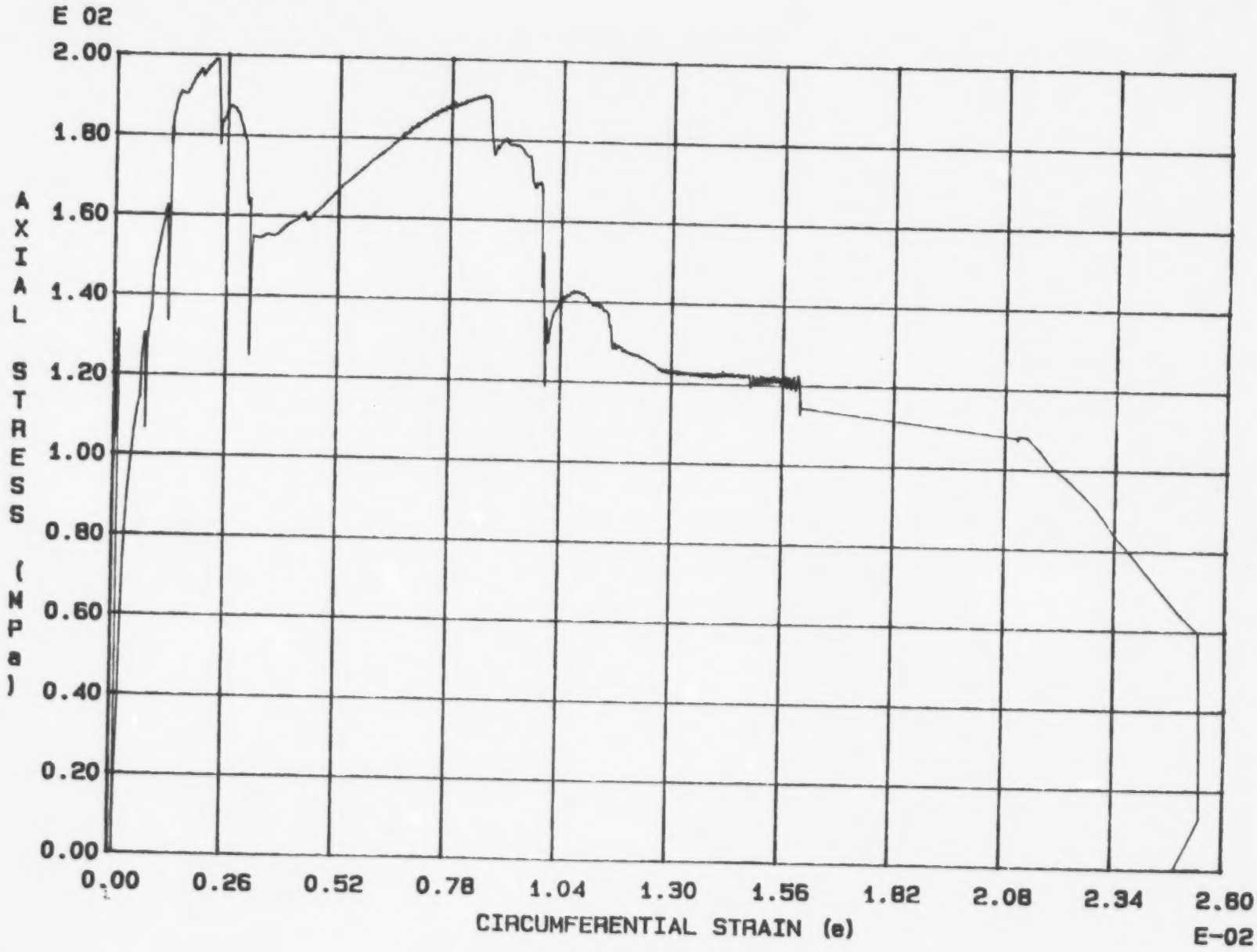

E 02
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
AXIAL STRESS (MPa)
0.00
0.26
0.52
0.78
1.04
1.30
1.56
1.82
2.08
2.34
2.60
CIRCUMFERENTIAL STRAIN (e)
E-02

Fig. F-2 E4T

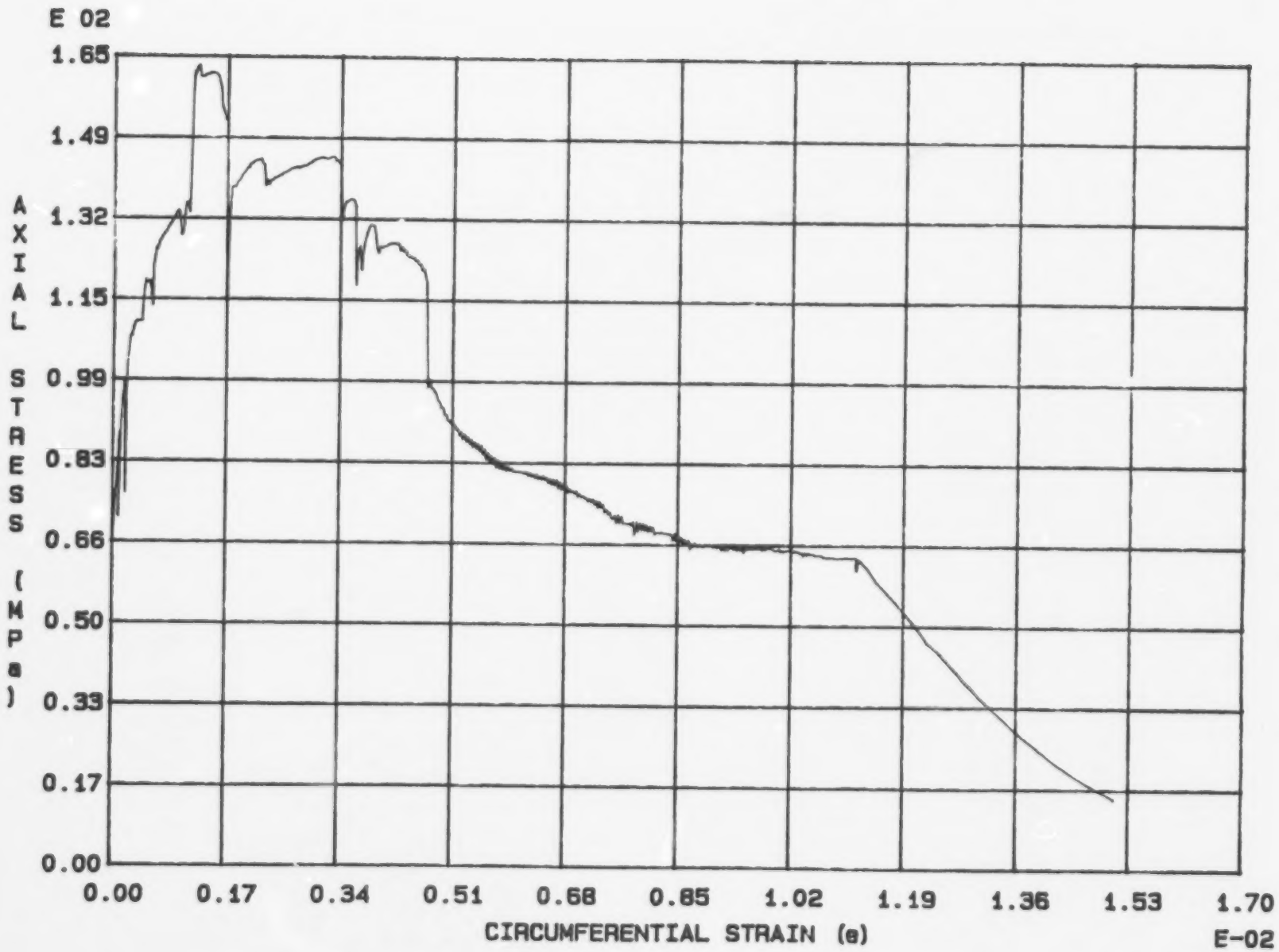

E 02
1.65
1.49
1.32
1.15
0.99
0.83
0.66
0.50
0.33
0.17
0.00
AXIAL STRESS (MPa)
0.00
0.17
0.34
0.51
0.68
0.85
1.02
1.19
1.36
1.53
1.70
CIRCUMFERENTIAL STRAIN (e)
E-02

Fig. F-3 E6T

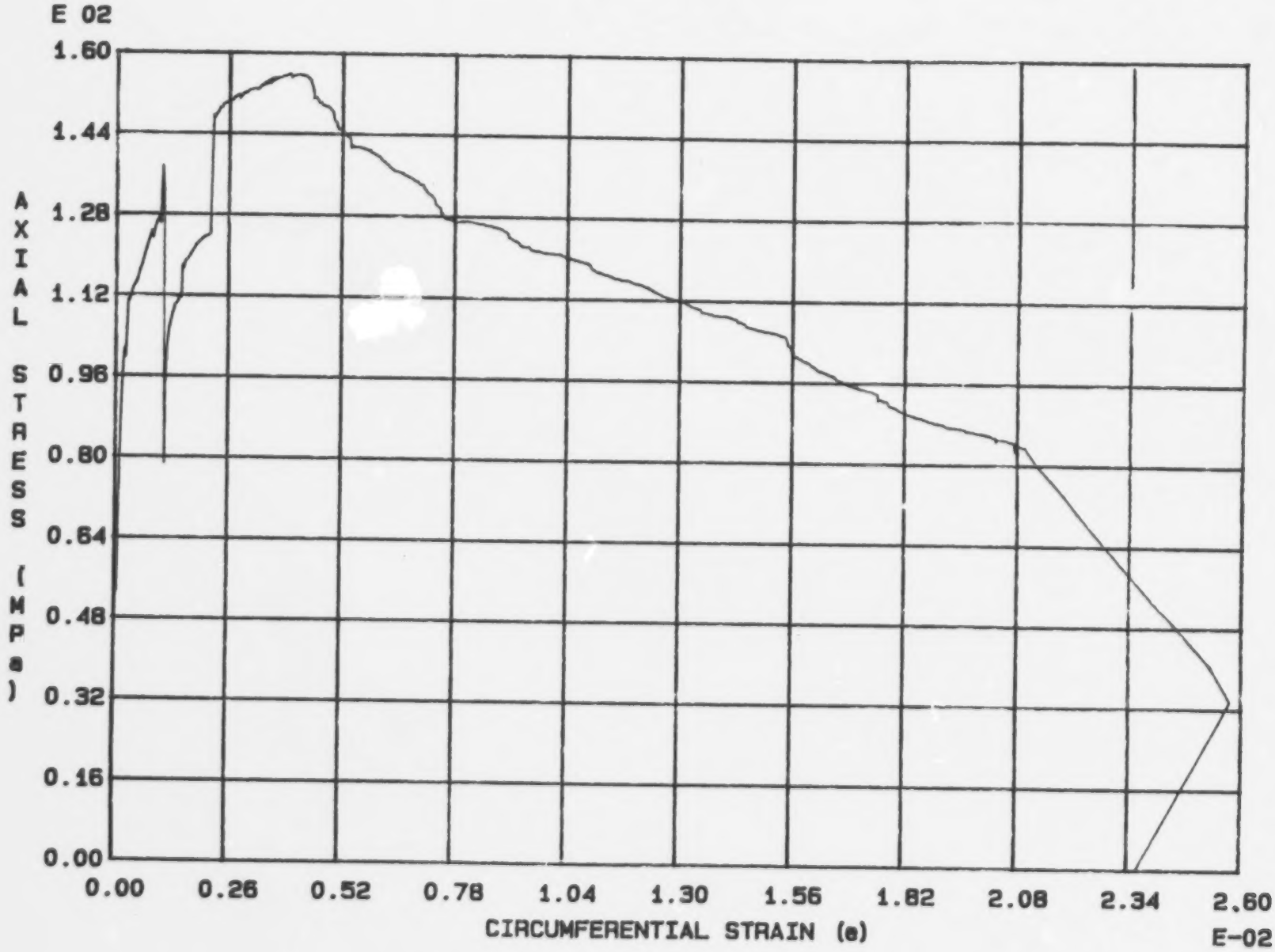

E 02
1.60
1.44
1.28
1.12
0.96
0.80
0.64
0.48
0.32
0.16
0.00
AXIAL STRESS (MPa)
0.00
0.26
0.52
0.78
1.04
1.30
1.56
1.82
2.08
2.34
2.60
CIRCUMFERENTIAL STRAIN (e)
E-02

Fig. F-4 E8T

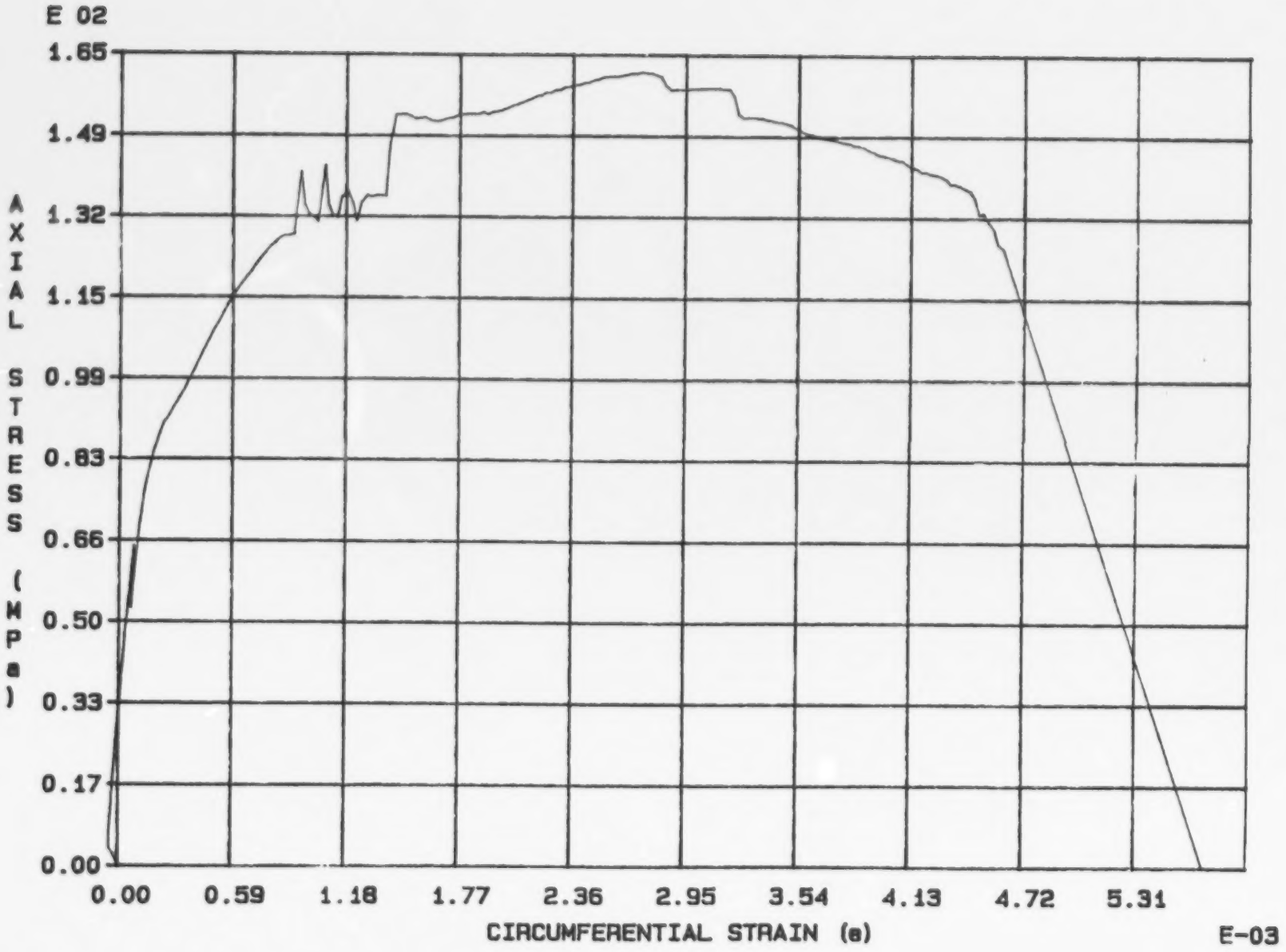

E 02
1.65
1.49
1.32
1.15
0.99
0.83
0.66
0.50
0.33
0.17
0.00
AXIAL STRESS (MPa)
0.00
0.59
1.18
1.77
2.36
2.95
3.54
4.13
4.72
5.31
CIRCUMFERENTIAL STRAIN (e)
E-03

Fig. F-5 E10T

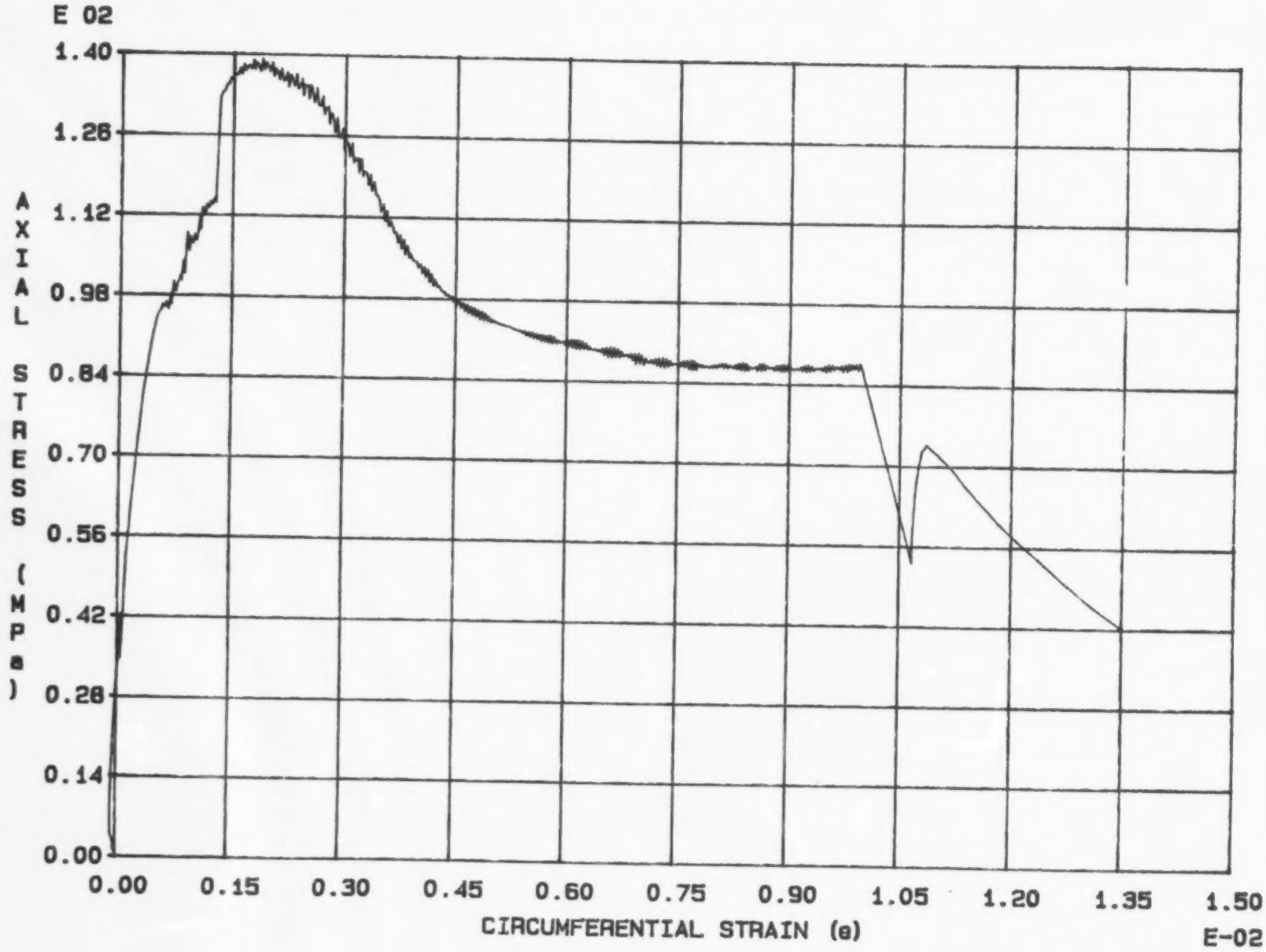

E 02
1.40
1.26
1.12
0.98
0.84
0.70
0.56
0.42
0.28
0.14
0.00
AXIAL STRESS (MPa)
0.00
0.15
0.30
0.45
0.60
0.75
0.90
1.05
1.20
1.35
1.50
CIRCUMFERENTIAL STRAIN (e)
E-02

Fig. F-6 E12T

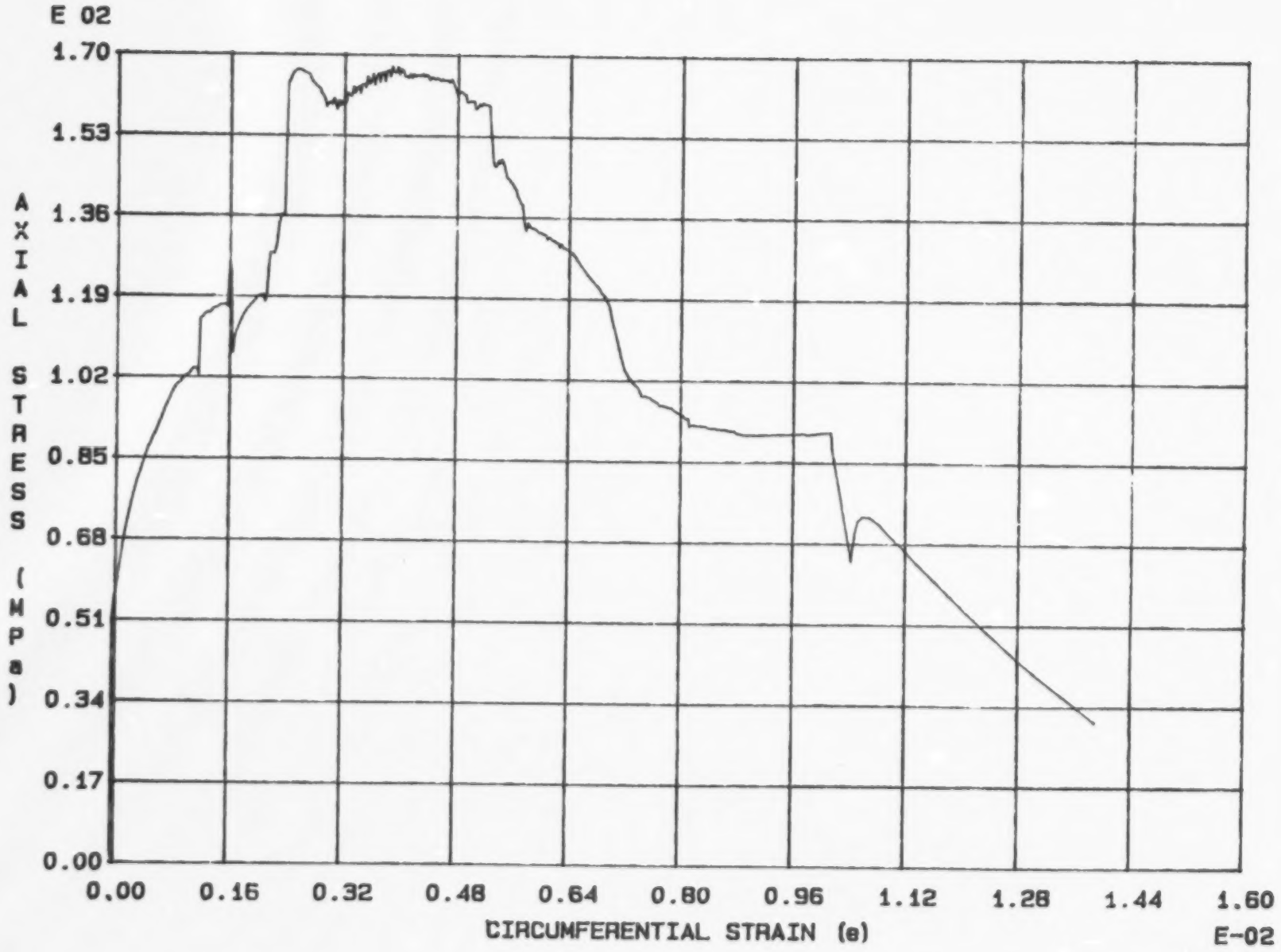

E 02
1.70
1.53
1.36
1.19
1.02
0.85
0.68
0.51
0.34
0.17
0.00
AXIAL STRESS (MPa)
0.00
0.16
0.32
0.48
0.64
0.80
0.96
1.12
1.28
1.44
1.60
CIRCUMFERENTIAL STRAIN (e)
E-02

Fig. F-7 E14T

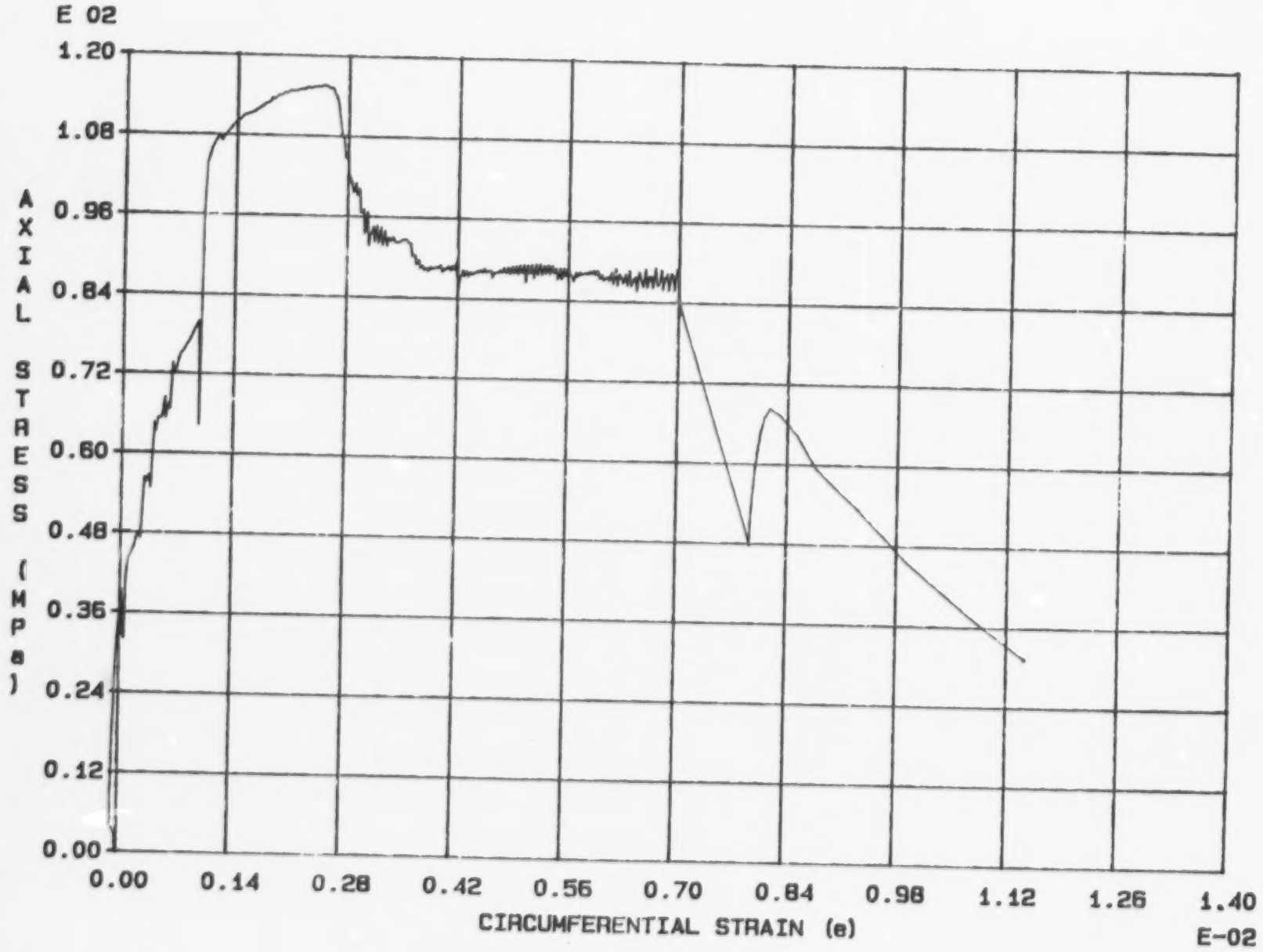

E 02
1.20
1.08
0.96
0.84
0.72
0.60
0.48
0.36
0.24
0.12
0.00
AXIAL STRESS (MPa)
0.00
0.14
0.28
0.42
0.56
0.70
0.84
0.98
1.12
1.26
1.40
CIRCUMFERENTIAL STRAIN (e)
E-02

Fig. F-8 E16T

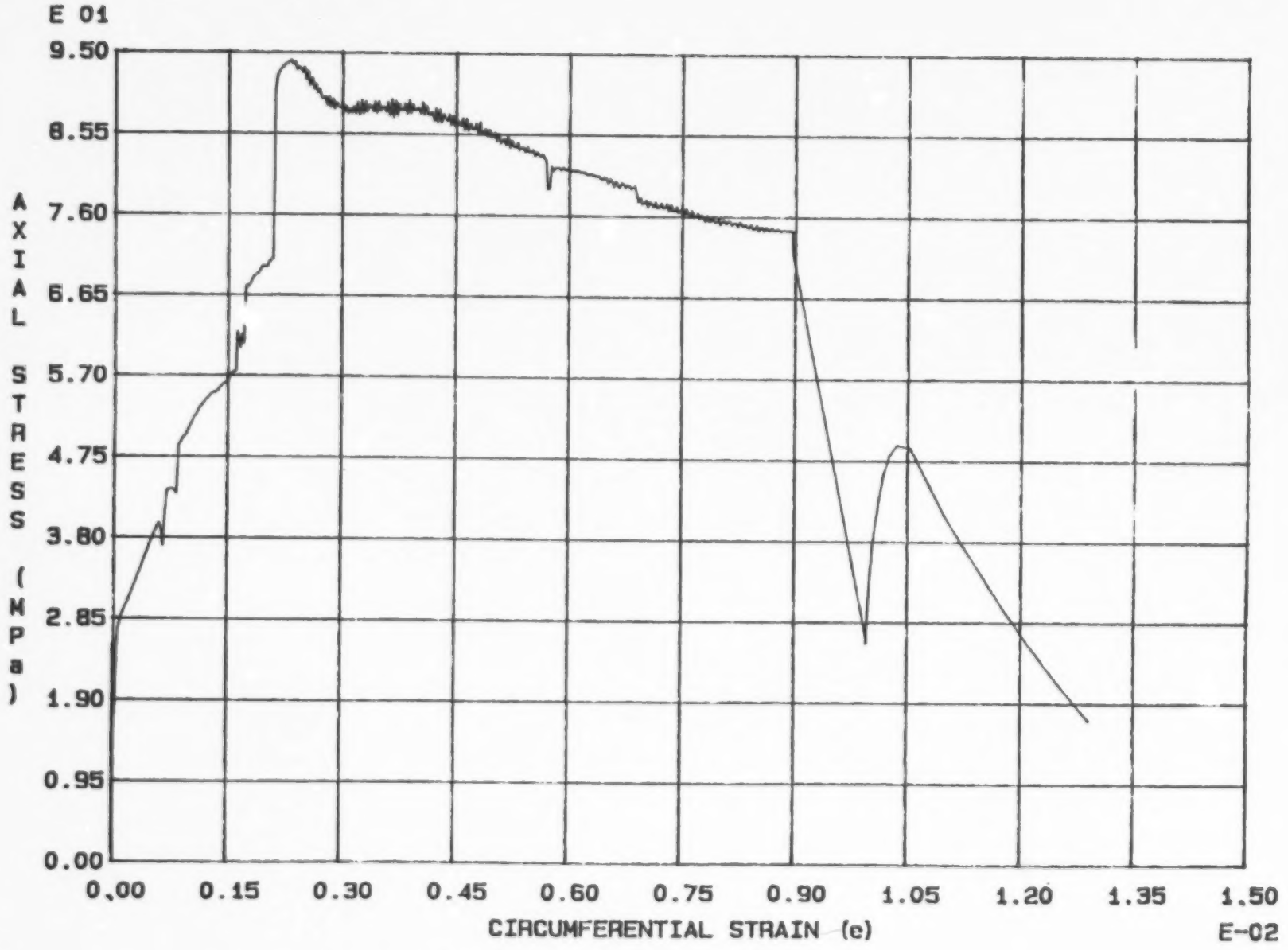

E 01
9.50
8.55
7.60
6.65
5.70
4.75
3.80
2.85
1.90
0.95
0.00
AXIAL STRESS (MPa)
0.00
0.15
0.30
0.45
0.60
0.75
0.90
1.05
1.20
1.35
1.50
CIRCUMFERENTIAL STRAIN (e)
E-02

Fig. F-9 E18T

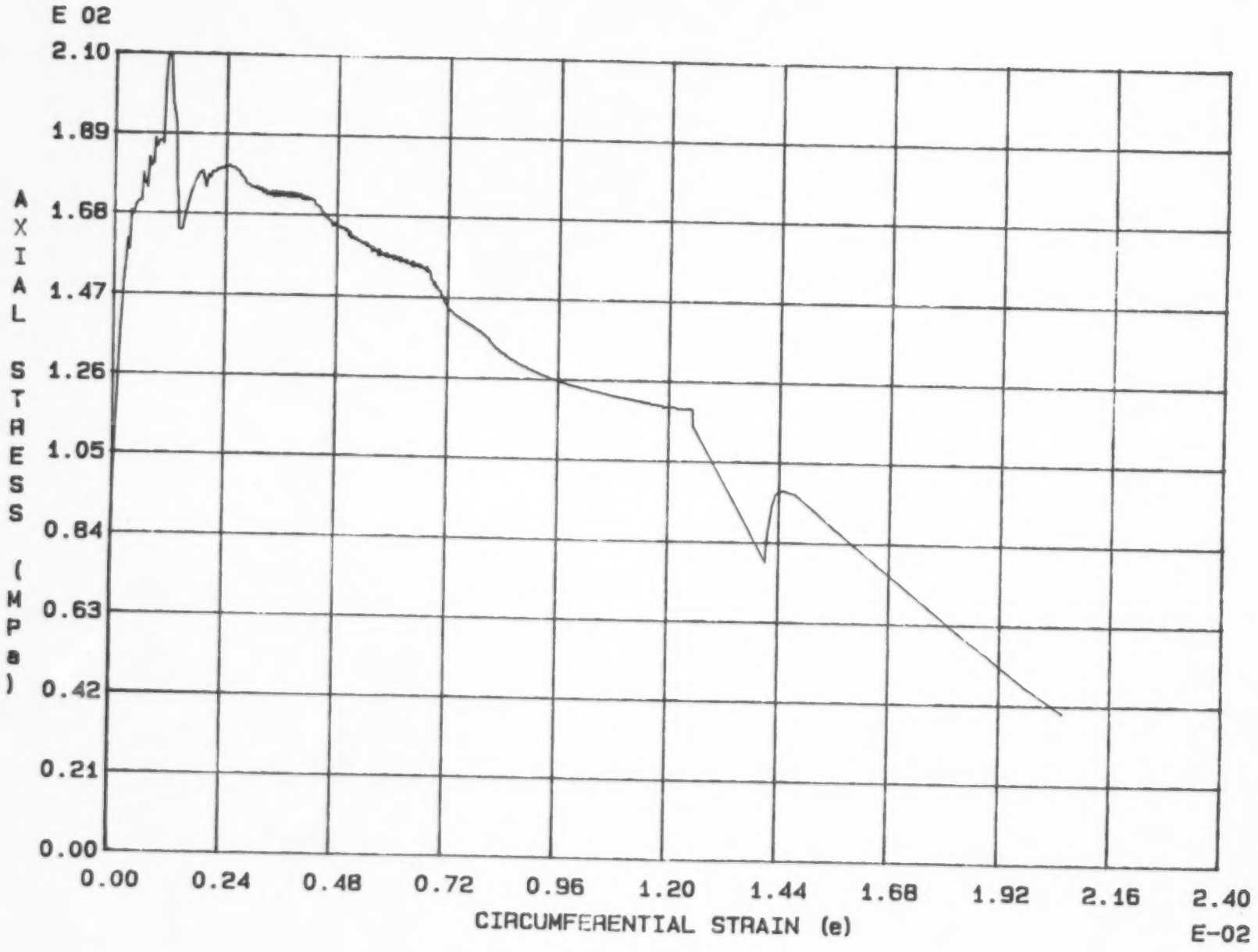

E 02
2.10
1.89
1.68
1.47
1.26
1.05
0.84
0.63
0.42
0.21
0.00
AXIAL STRESS (MPa)
0.00
0.24
0.48
0.72
0.96
1.20
1.44
1.68
1.92
2.16
2.40
CIRCUMFERENTIAL STRAIN (e)
E-02

Fig. F-10 E20T

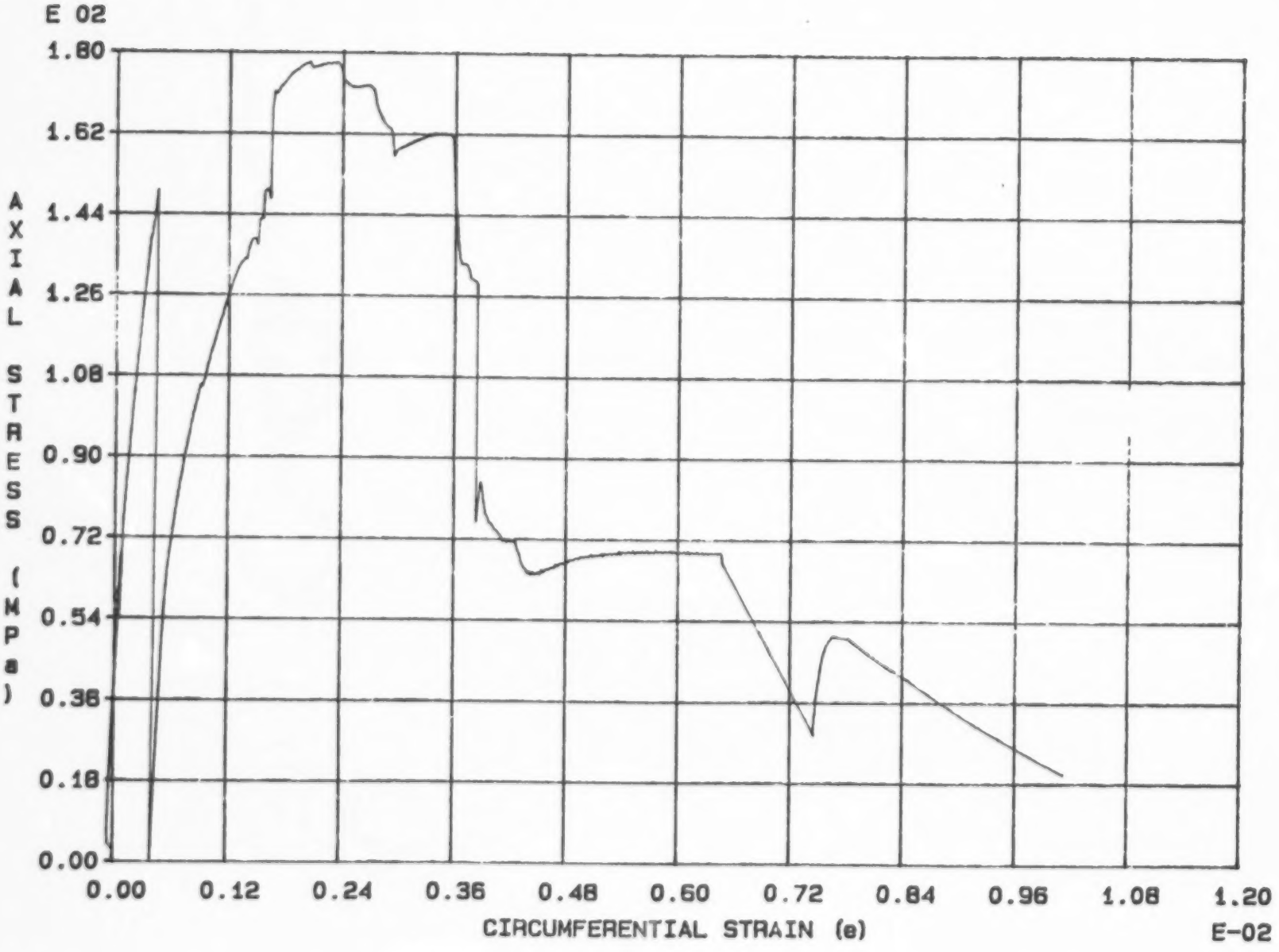

E 02
1.80
1.62
1.44
1.26
1.08
0.90
0.72
0.54
0.36
0.18
0.00
AXIAL STRESS (MPa)
0.00
0.12
0.24
0.36
0.48
0.60
0.72
0.84
0.96
1.08
1.20
CIRCUMFERENTIAL STRAIN (e)
E-02

Fig. F-11 E22T

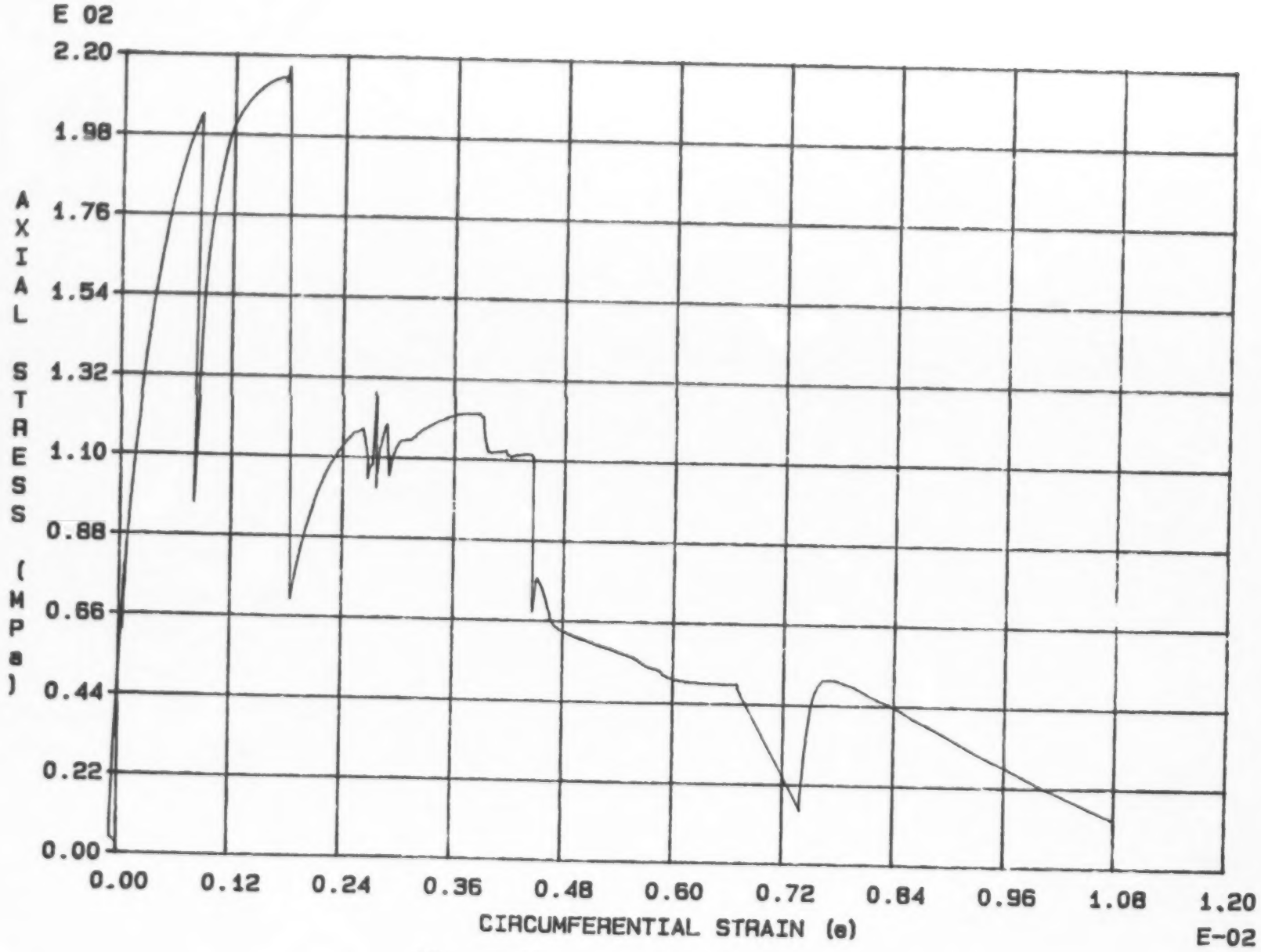

E 02
2.20
1.98
1.76
1.54
1.32
1.10
0.88
0.66
0.44
0.22
0.00
AXIAL STRESS (MPa)
0.00
0.12
0.24
0.36
0.48
0.60
0.72
0.84
0.96
1.08
1.20
E-02
CIRCUMFERENTIAL STRAIN (e)

Fig. F-12 E24T

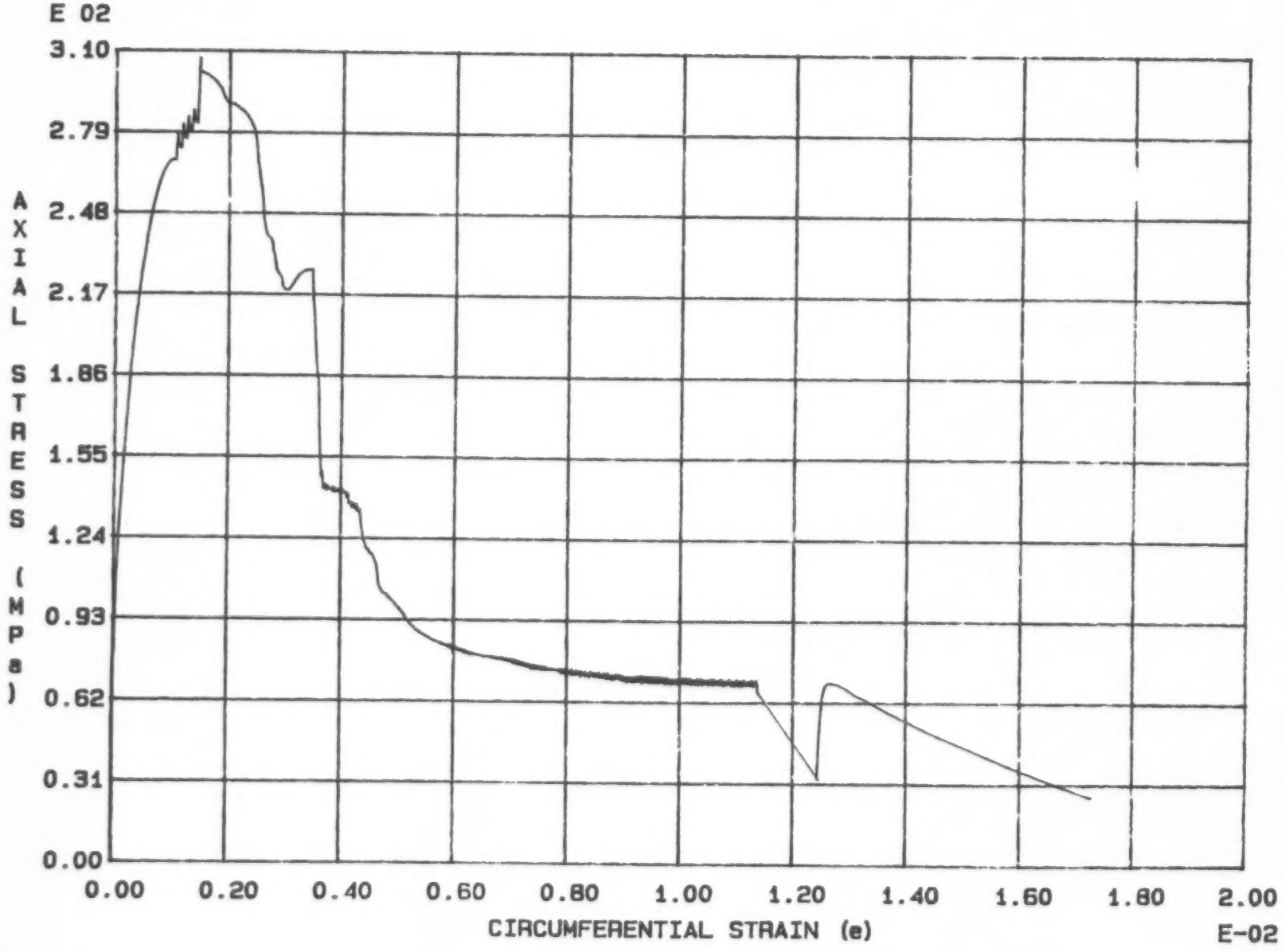

E 02
3.10
2.79
2.48
2.17
1.86
1.55
1.24
0.93
0.62
0.31
0.00
AXIAL STRESS (MPa)
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
1.60
1.80
2.00
CIRCUMFERENTIAL STRAIN (e)
E-02

Fig. F-13 E26T

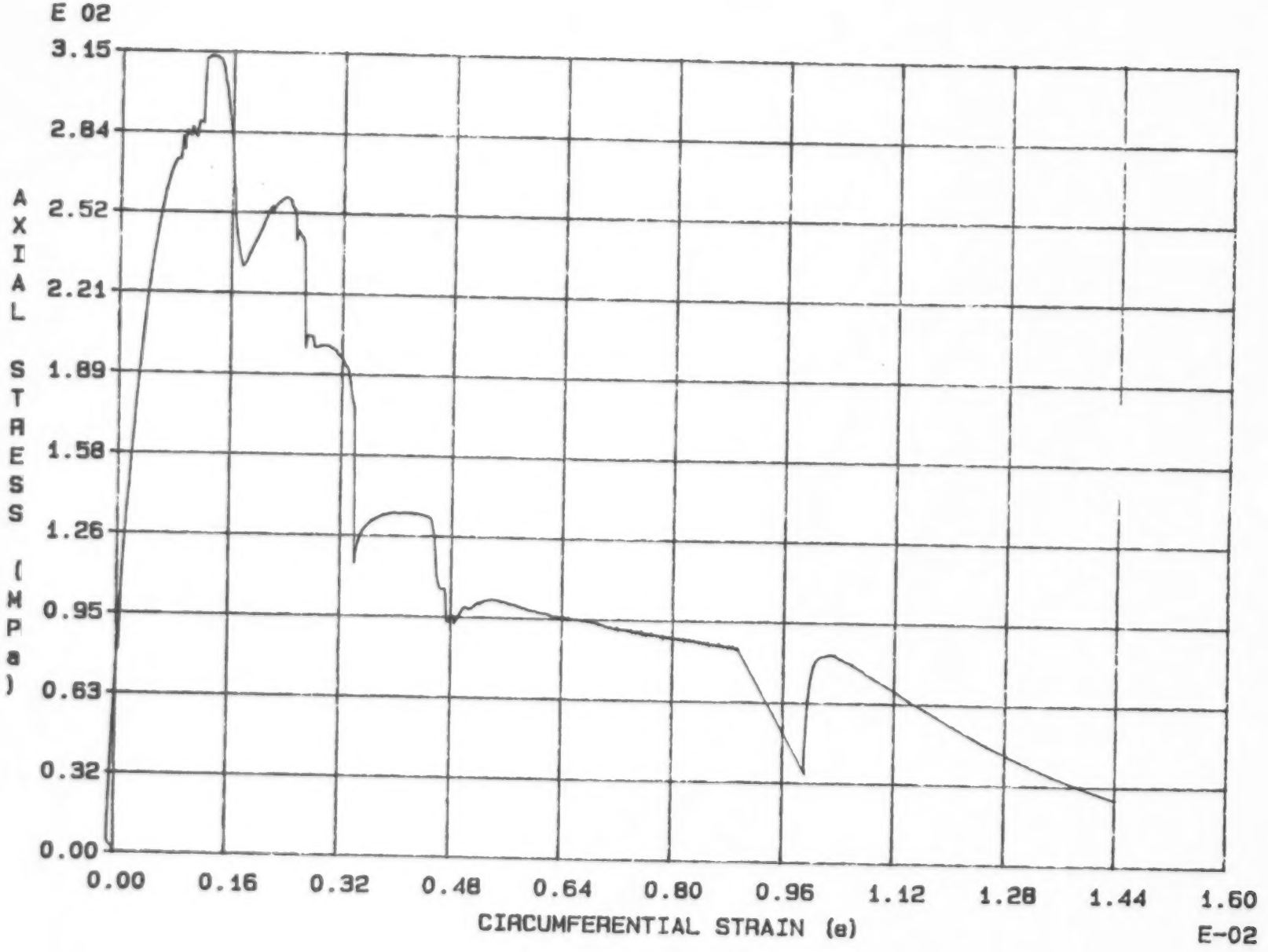

E 02
3.15
2.84
2.52
2.21
1.89
1.58
1.26
0.95
0.63
0.32
0.00
AXIAL STRESS (MPa)
0.00
0.16
0.32
0.48
0.64
0.80
0.96
1.12
1.28
1.44
1.60
CIRCUMFERENTIAL STRAIN (e)
E-02

Fig. F-14 E28T

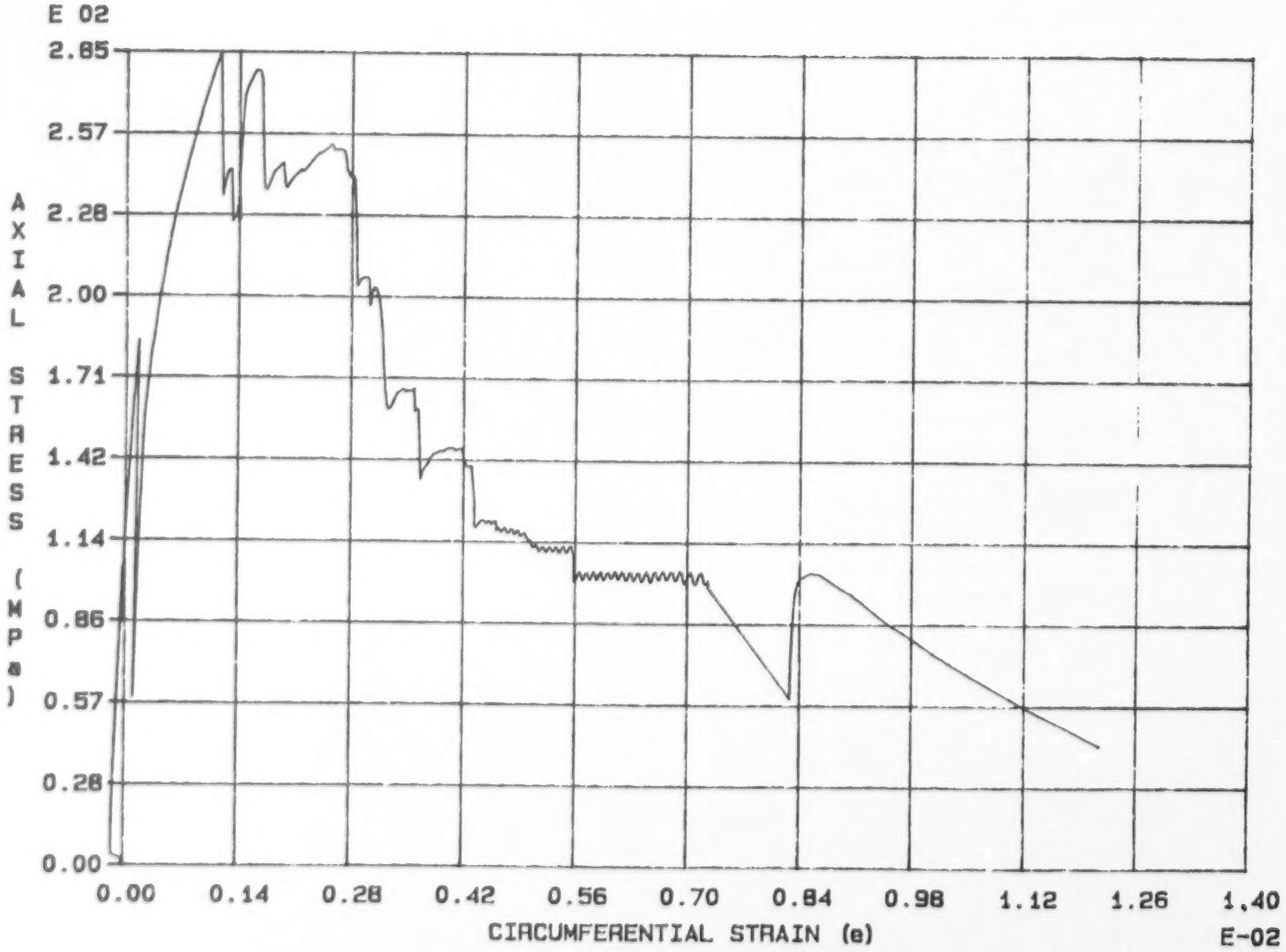

E 02
2.85
2.57
2.28
2.00
1.71
1.42
1.14
0.86
0.57
0.28
0.00
AXIAL STRESS (MPa)
0.00
0.14
0.28
0.42
0.56
0.70
0.84
0.98
1.12
1.26
1.40
E-02
CIRCUMFERENTIAL STRAIN (e)

Fig. F-15 E30T

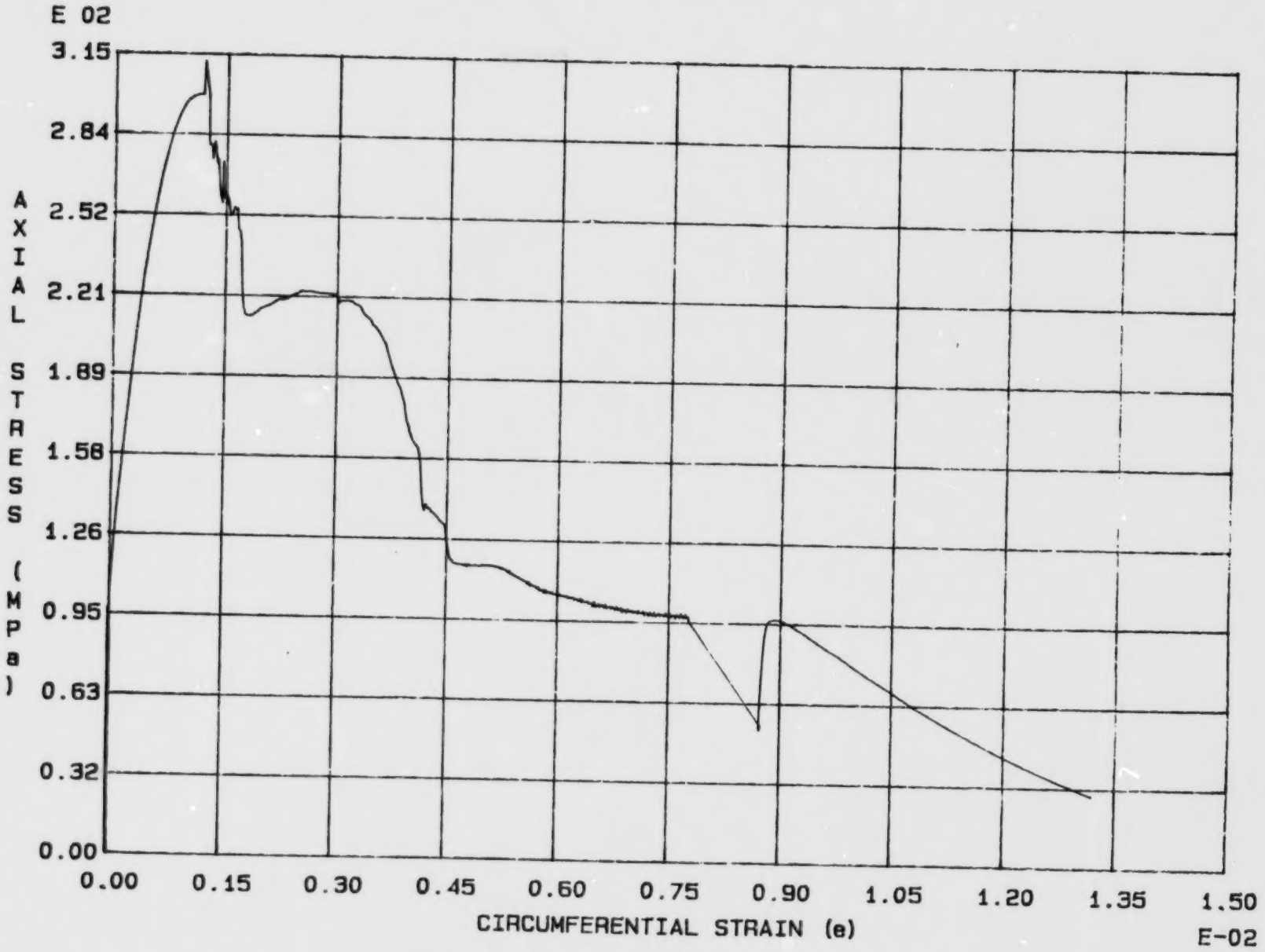

E 02
3.15
2.84
2.52
2.21
1.89
1.58
1.26
0.95
0.63
0.32
0.00
AXIAL STRESS (MPa)
0.00
0.15
0.30
0.45
0.60
0.75
0.90
1.05
1.20
1.35
1.50
CIRCUMFERENTIAL STRAIN (e)
E-02

Fig. F-16 E32T

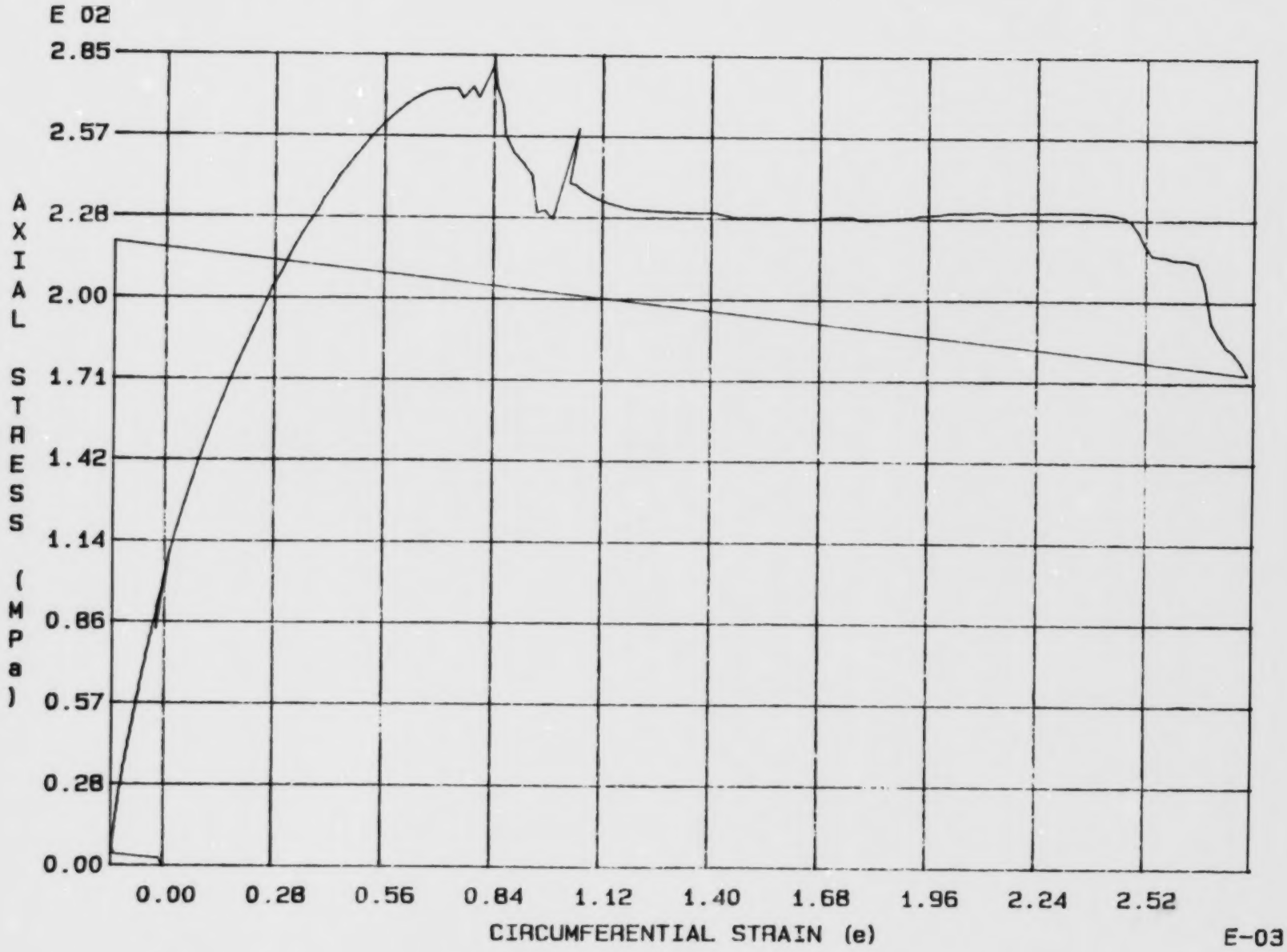

E 02
2.85
2.57
2.28
2.00
1.71
1.42
1.14
0.86
0.57
0.28
0.00
AXIAL STRESS (MPa)
0.00
0.28
0.56
0.84
1.12
1.40
1.68
1.96
2.24
2.52
CIRCUMFERENTIAL STRAIN (e)
E-03

Fig. F-17 E34T

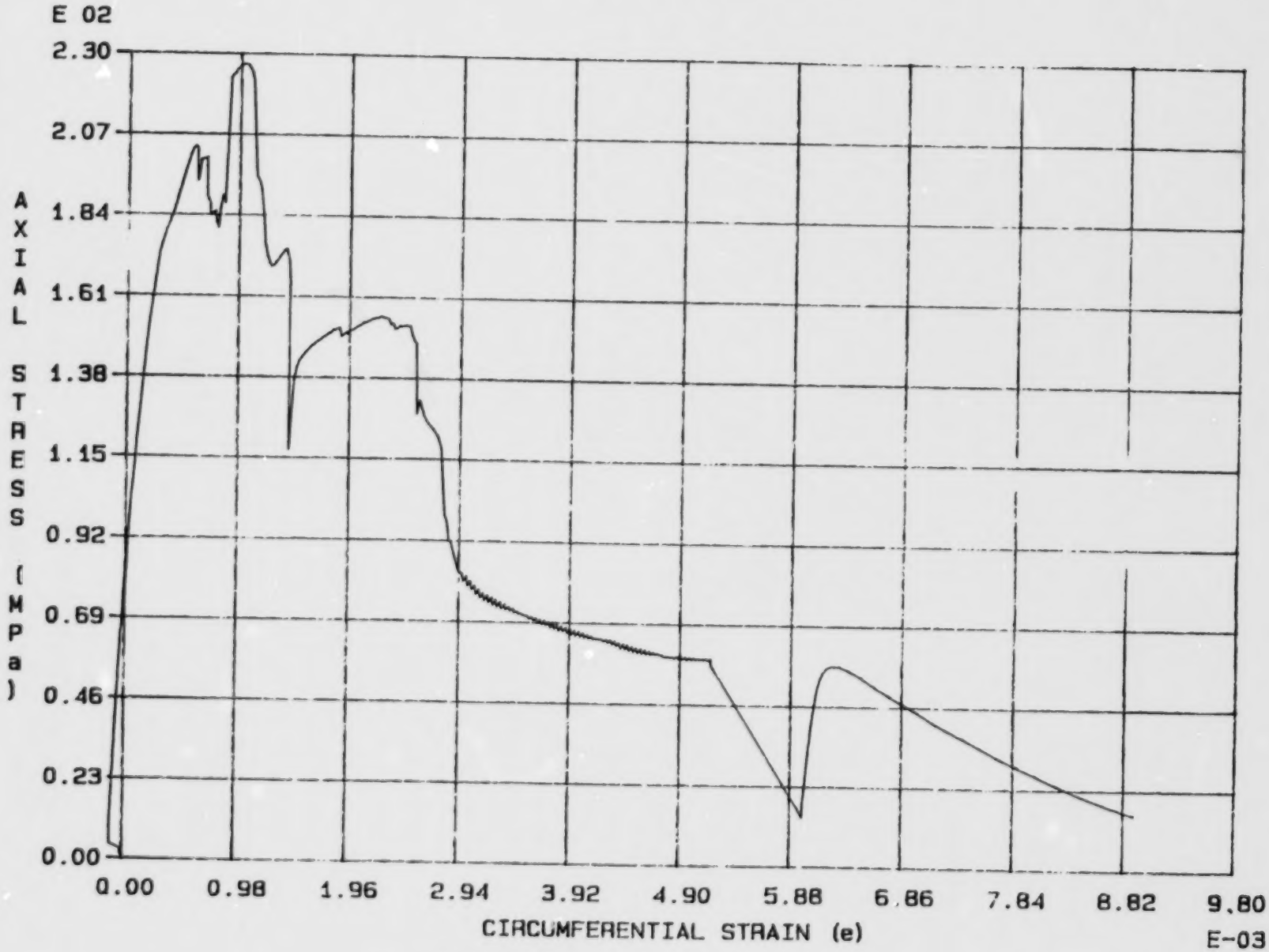

E 02
2.30
2.07
1.84
1.61
1.38
1.15
0.92
0.69
0.46
0.23
0.00
AXIAL STRESS (MPa)
0.00
0.98
1.96
2.94
3.92
4.90
5.88
6.86
7.84
8.82
9.80
E-03
CIRCUMFERENTIAL STRAIN (e)

Fig. F-18 E36T

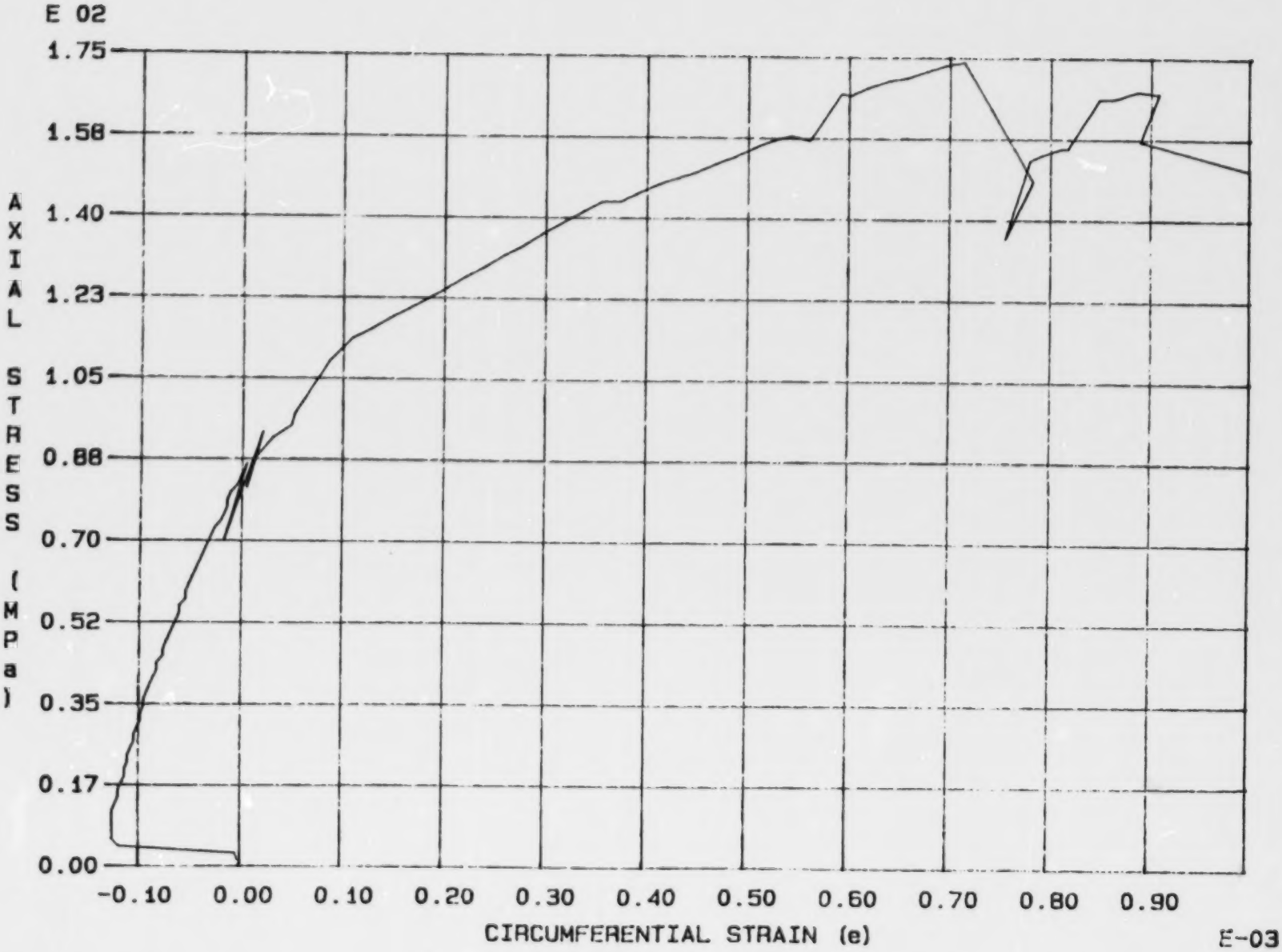

E 02
1.75
1.58
1.40
1.23
1.05
0.88
0.70
0.52
0.35
0.17
0.00
AXIAL STRESS (MPa)
-0.10
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
CIRCUMFERENTIAL STRAIN (e)
E-03

Fig. F-19 E38T

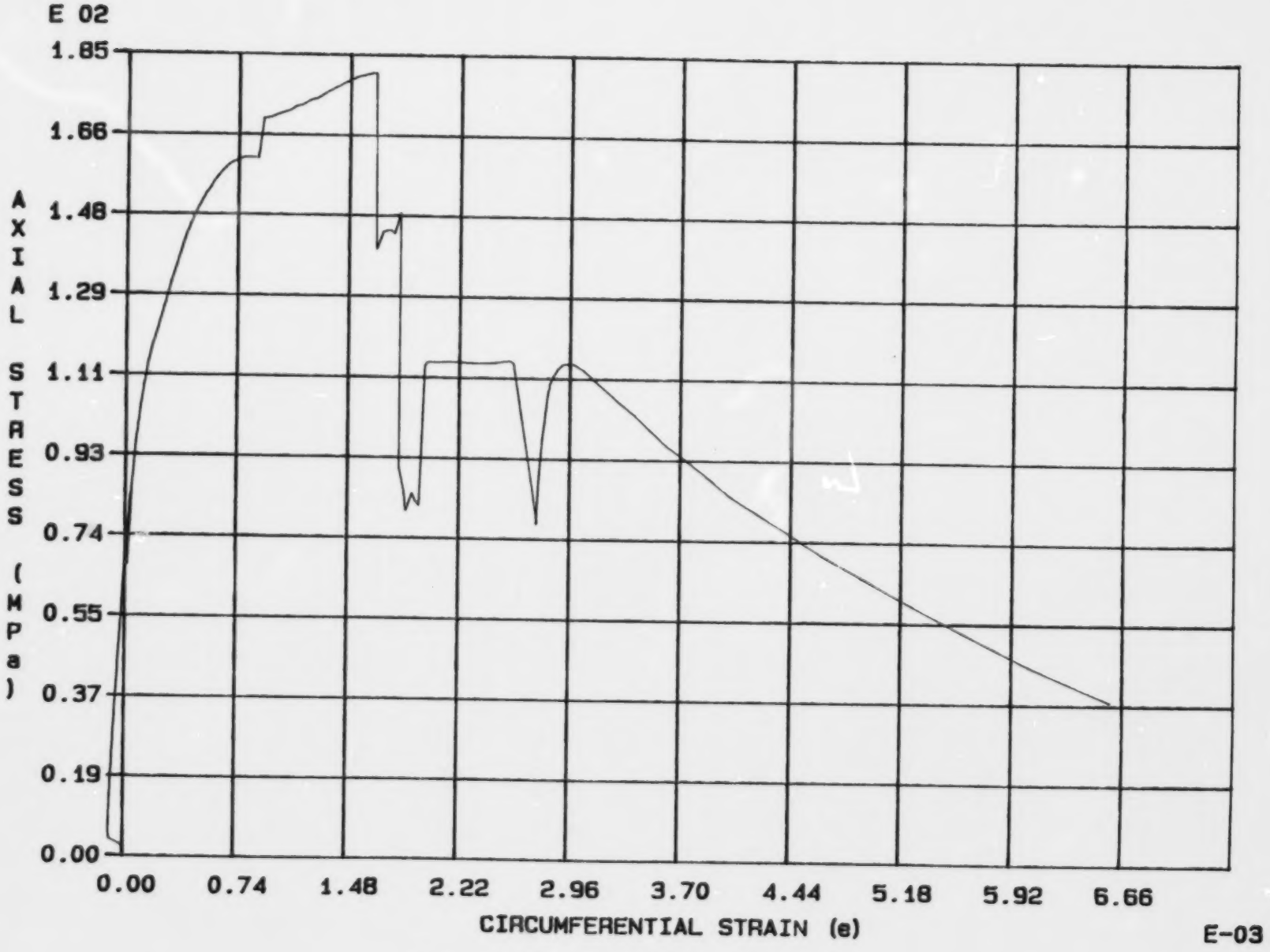

E 02
1.85
1.66
1.48
1.29
1.11
0.93
0.74
0.55
0.37
0.19
0.00
AXIAL STRESS (MPa)
0.00
0.74
1.48
2.22
2.96
3.70
4.44
5.18
5.92
6.66
CIRCUMFERENTIAL STRAIN (e)
E-03

Fig. F-20 E40T

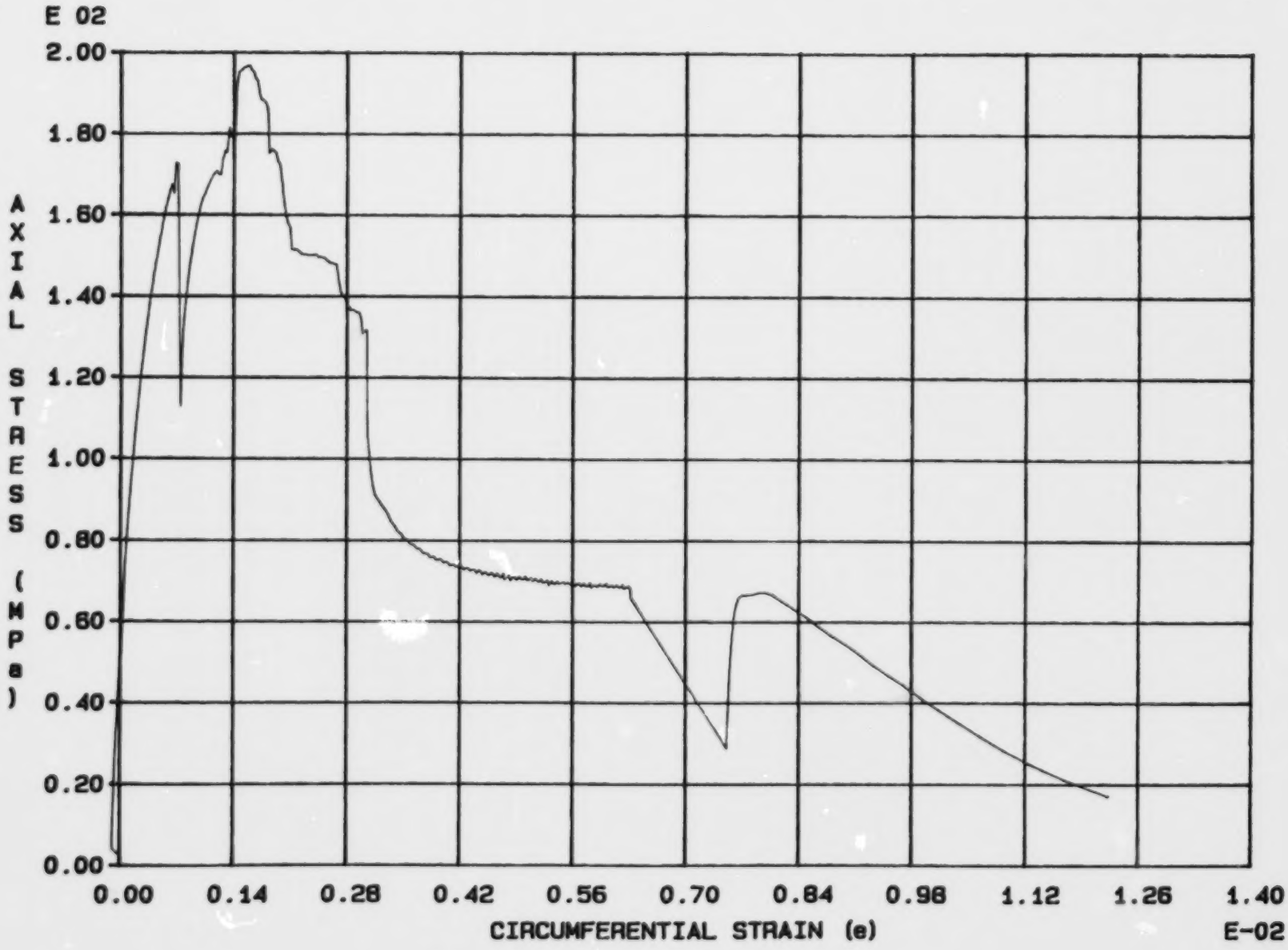

E 02
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
AXIAL STRESS (MPa)
0.00
0.14
0.28
0.42
0.56
0.70
0.84
0.98
1.12
1.26
1.40
CIRCUMFERENTIAL STRAIN (e)
E-02

Fig. F-21 E42T

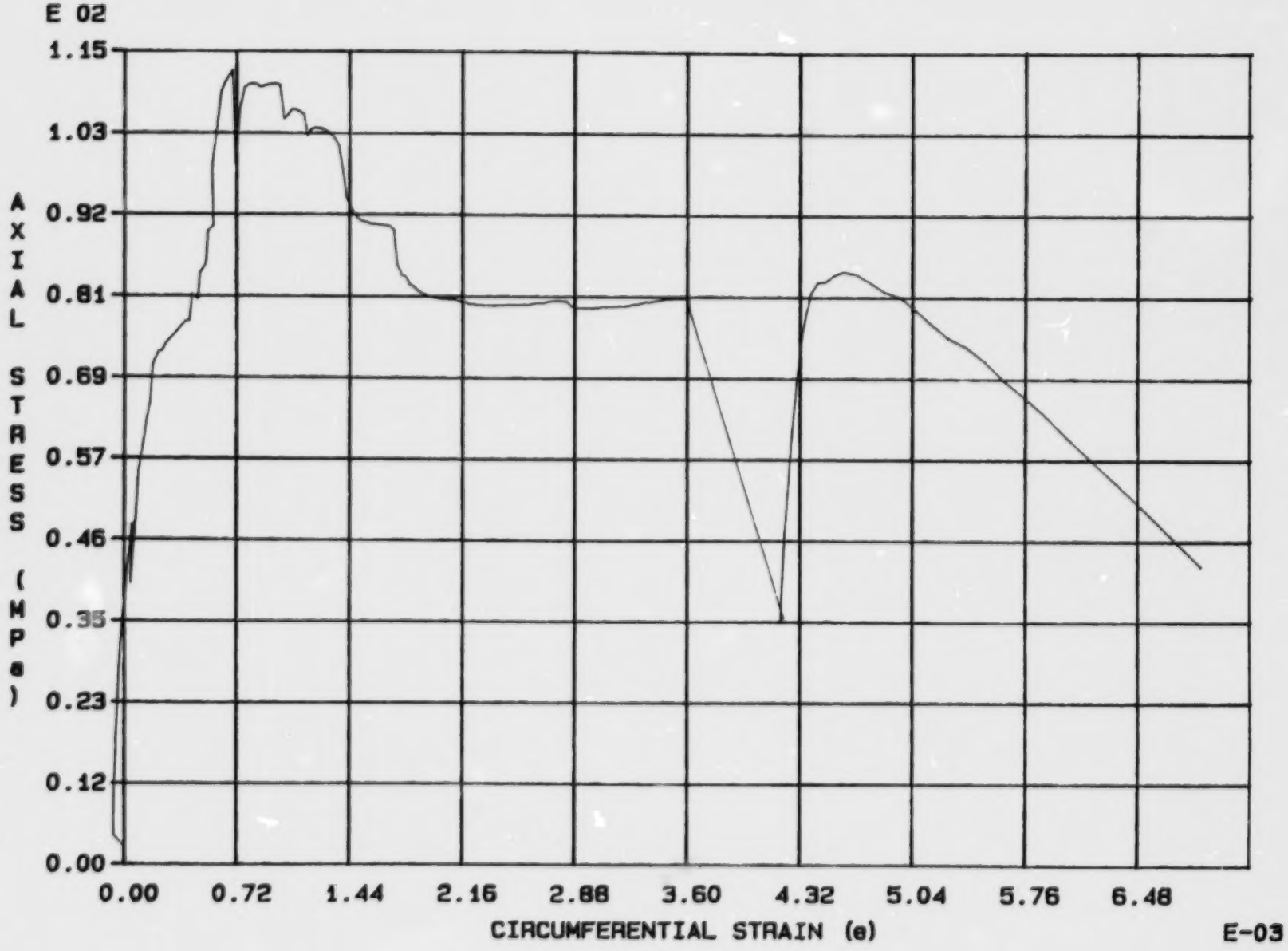

E 02
1.15
1.03
0.92
0.81
0.69
0.57
0.46
0.35
0.23
0.12
0.00
AXIAL STRESS (MPa)
0.00
0.72
1.44
2.16
2.88
3.60
4.32
5.04
5.76
6.48
CIRCUMFERENTIAL STRAIN (e)
E-03

Fig. F-22 E44T

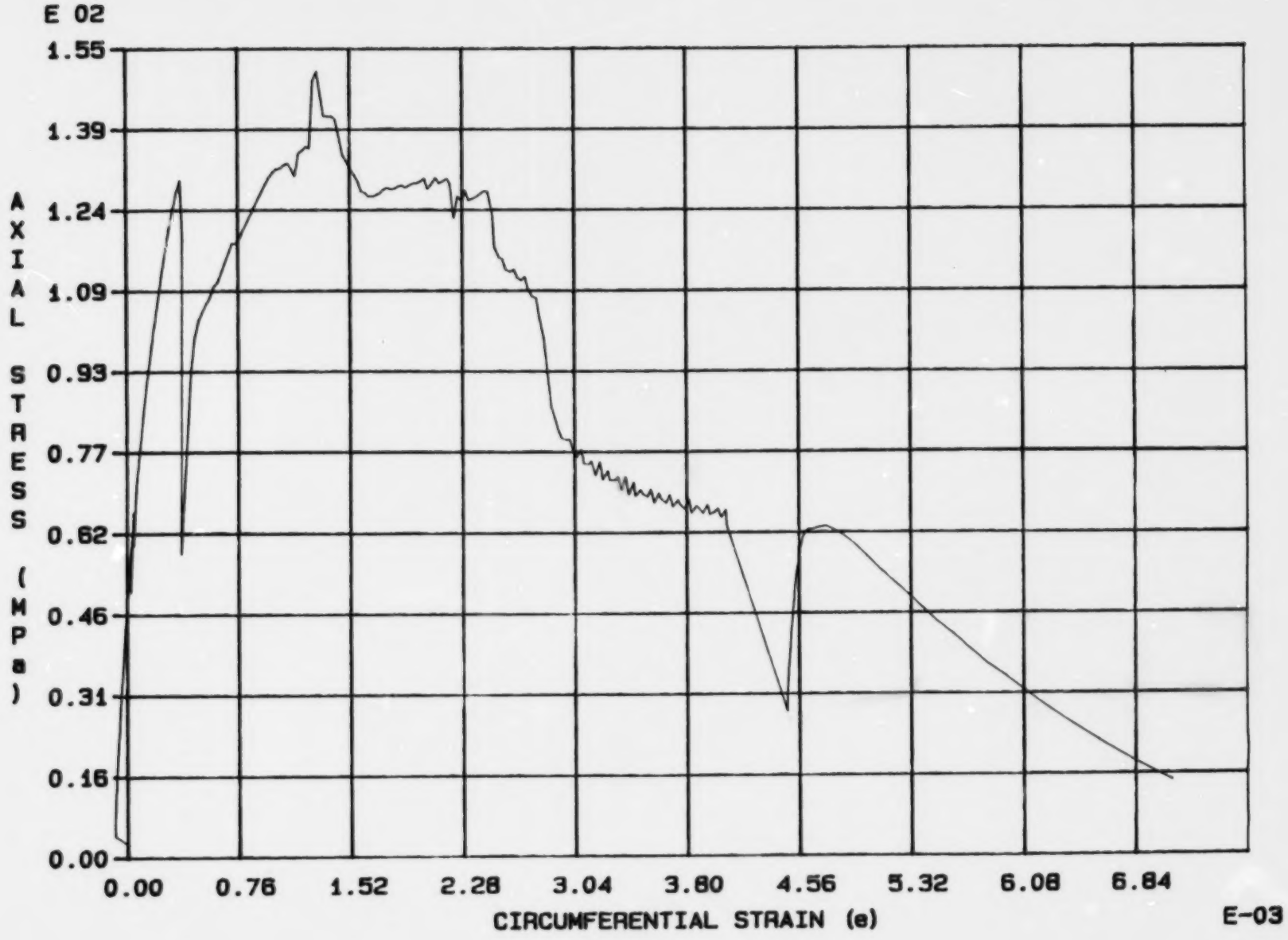

E 02
1.55
1.39
1.24
1.09
0.93
0.77
0.62
0.46
0.31
0.16
0.00
AXIAL STRESS (MPa)
0.00
0.76
1.52
2.28
3.04
3.80
4.56
5.32
6.08
6.84
CIRCUMFERENTIAL STRAIN (e)
E-03

Fig. F-23 E46T

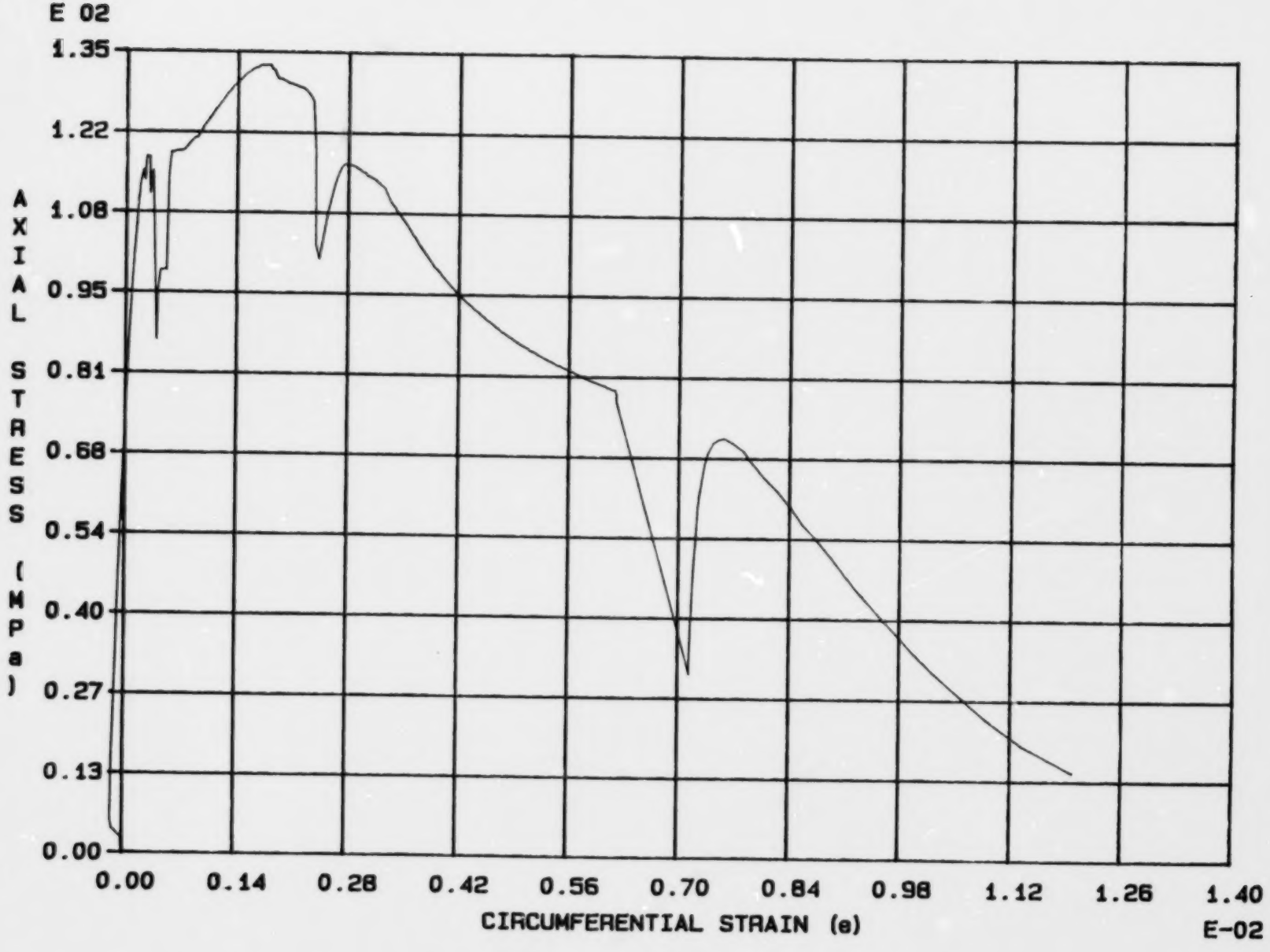

E 02
1.35
1.22
1.08
0.95
0.81
0.68
0.54
0.40
0.27
0.13
0.00
AXIAL STRESS (MPa)
0.00
0.14
0.28
0.42
0.56
0.70
0.84
0.98
1.12
1.26
1.40
CIRCUMFERENTIAL STRAIN (e)
E-02

Fig. F-24 E48T

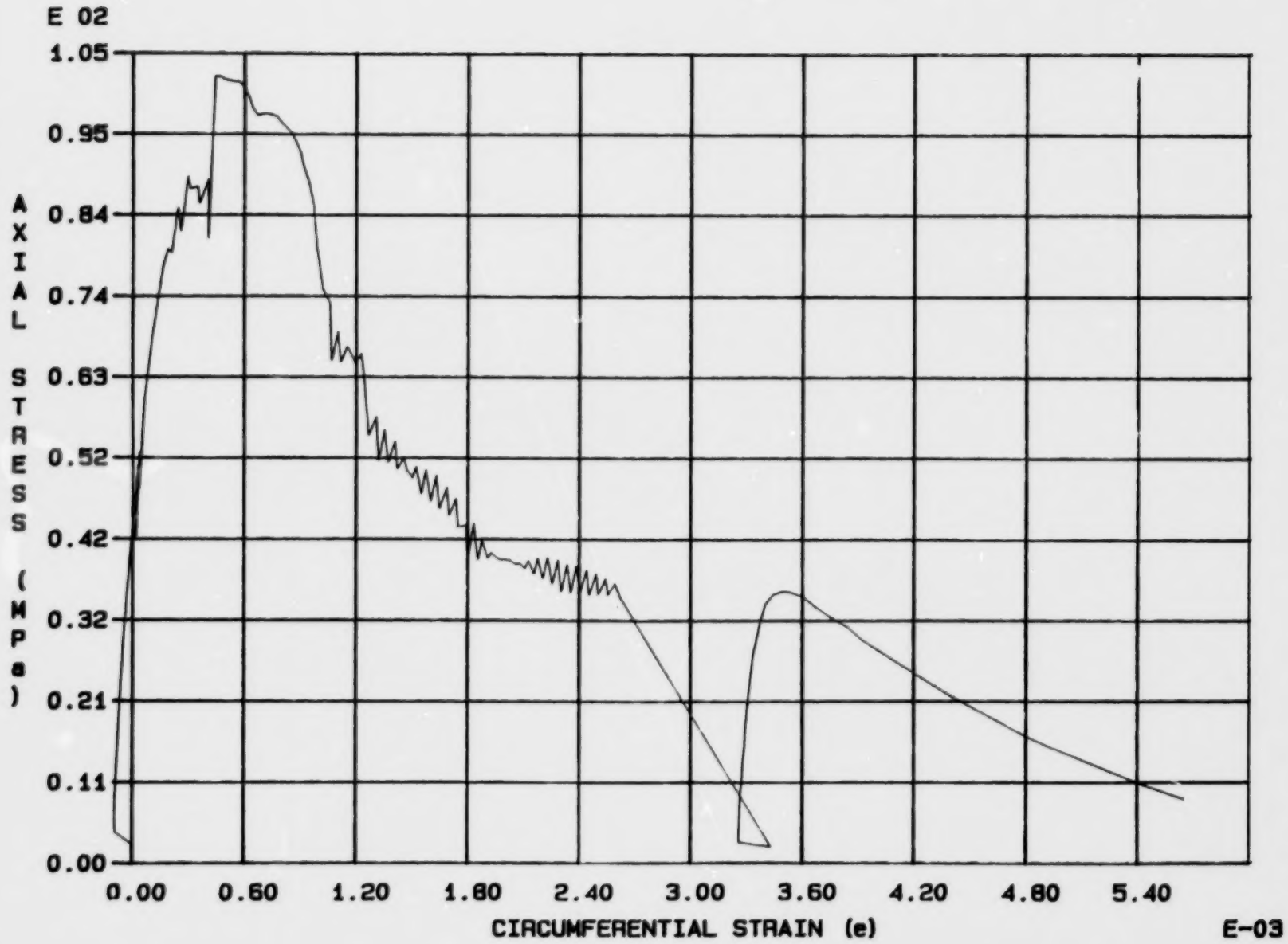

E 02
1.05
0.95
0.84
0.74
0.63
0.52
0.42
0.32
0.21
0.11
0.00
AXIAL STRESS (MPa)
0.00
0.60
1.20
1.80
2.40
3.00
3.60
4.20
4.80
5.40
CIRCUMFERENTIAL STRAIN (e)
E-03

Fig. F-25 E50T

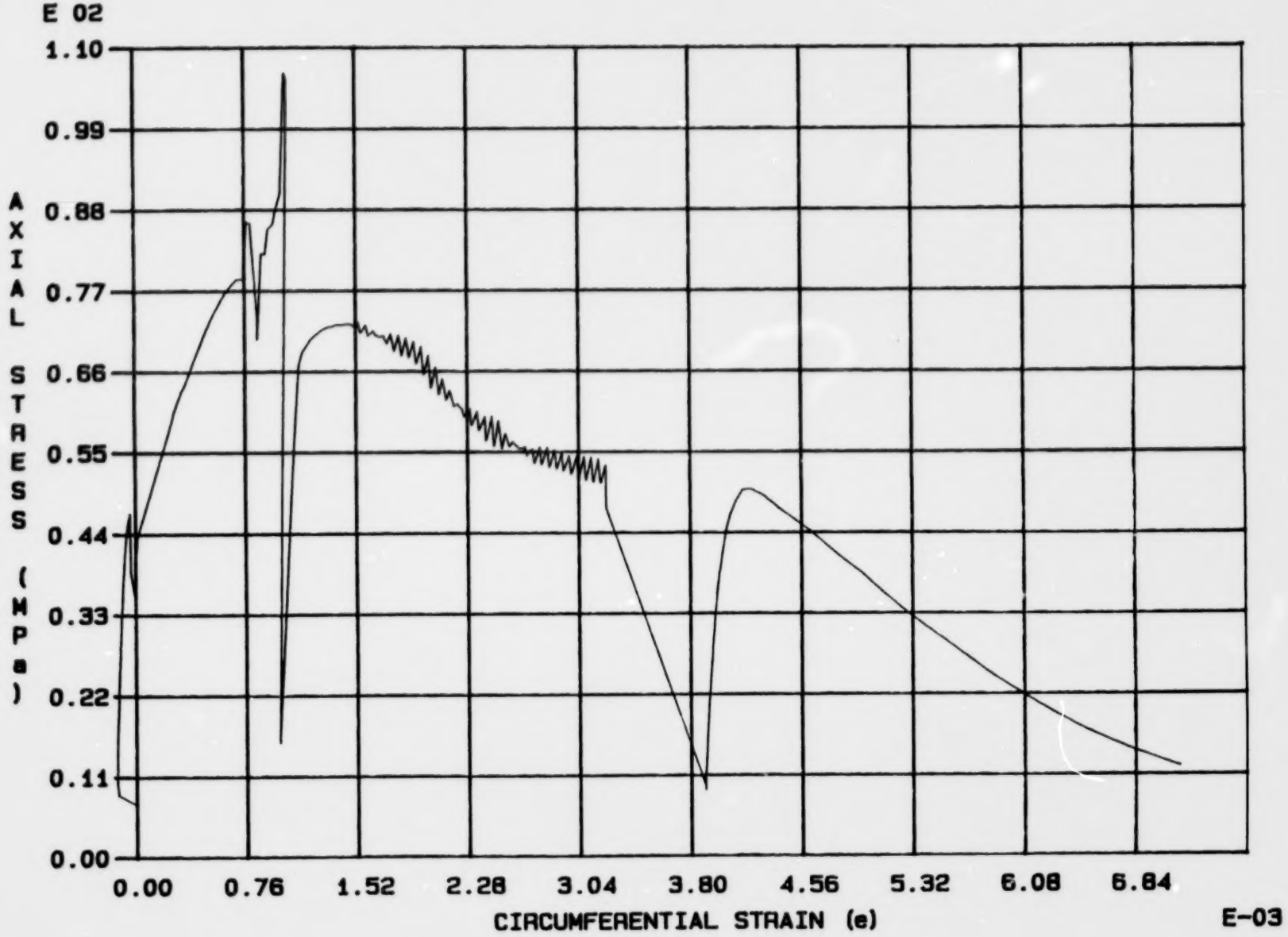

E 02
1.10
0.99
0.88
0.77
0.66
0.55
0.44
0.33
0.22
0.11
0.00
AXIAL STRESS (MPa)
0.00
0.76
1.52
2.28
3.04
3.80
4.56
5.32
6.08
6.84
CIRCUMFERENTIAL STRAIN (e)
E-03

Fig. F-26 E52T

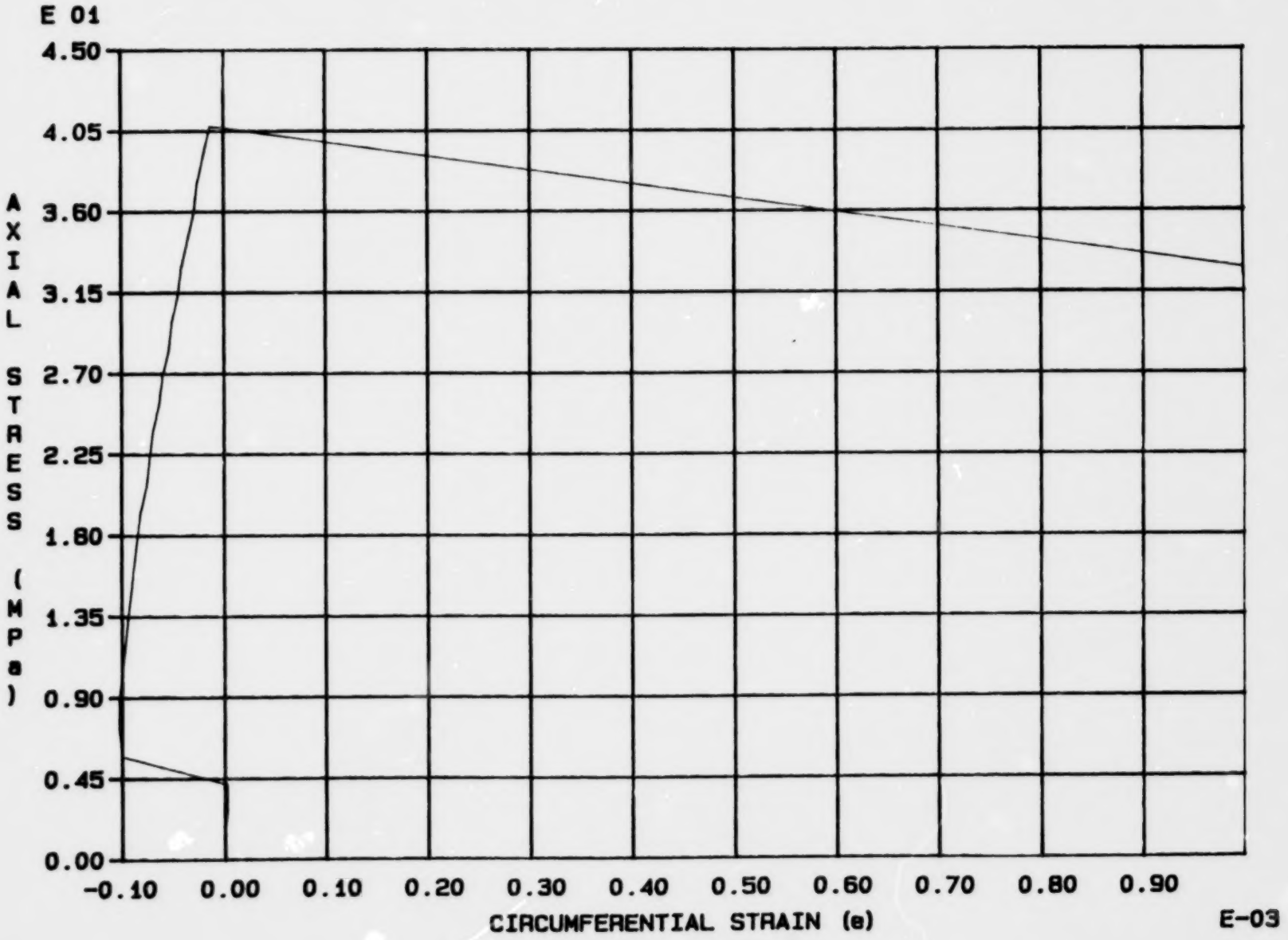

E 01
4.50
4.05
3.60
3.15
2.70
2.25
1.80
1.35
0.90
0.45
0.00
AXIAL STRESS (MPa)
-0.10
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
CIRCUMFERENTIAL STRAIN (e)
E-03

Fig. F-27 E54T

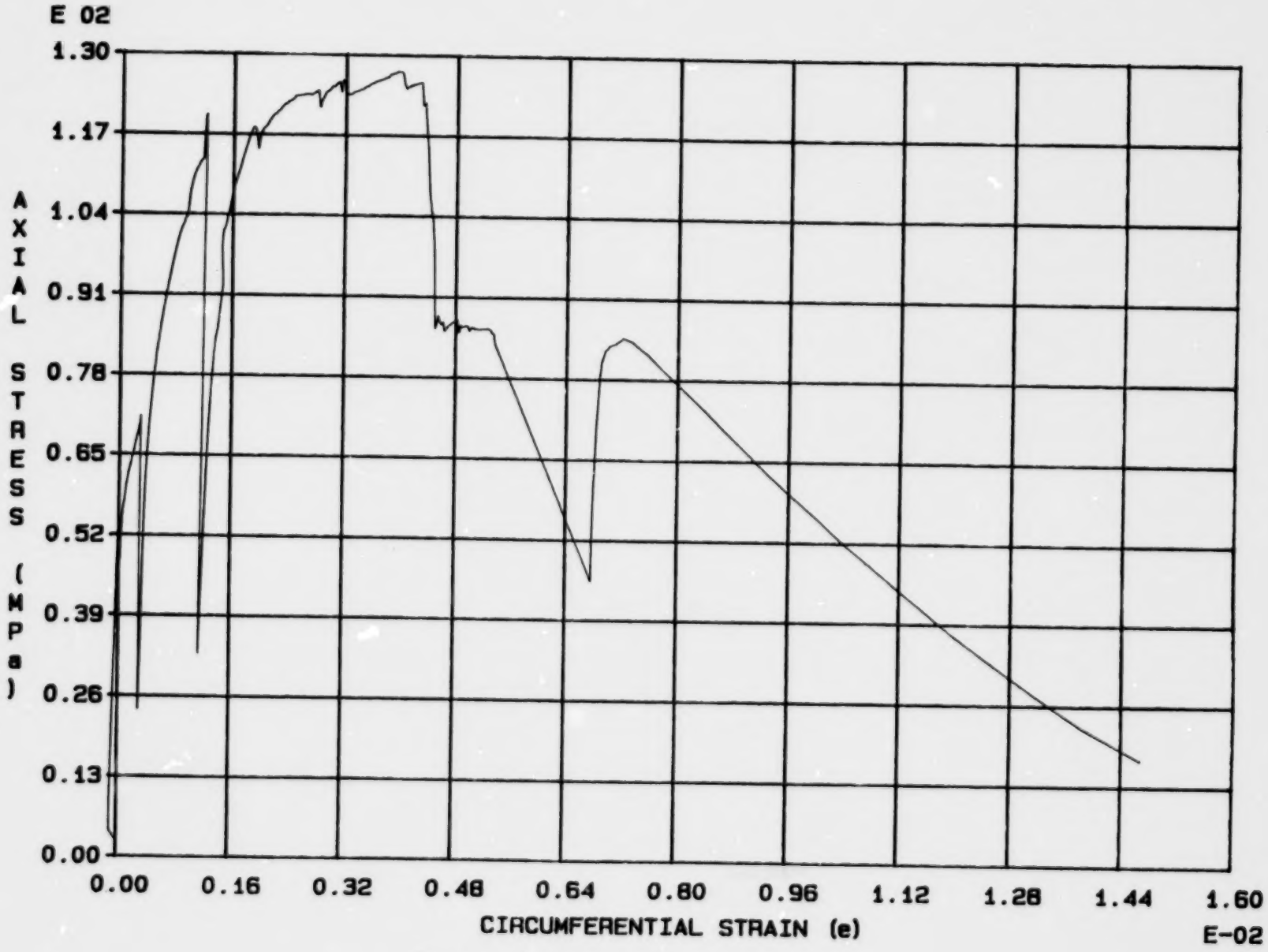

E 02
1.30
1.17
1.04
0.91
0.78
0.65
0.52
0.39
0.26
0.13
0.00
AXIAL STRESS (MPa)
0.00
0.16
0.32
0.48
0.64
0.80
0.96
1.12
1.28
1.44
1.60
CIRCUMFERENTIAL STRAIN (e)
E-02

Fig. F-28 E56T

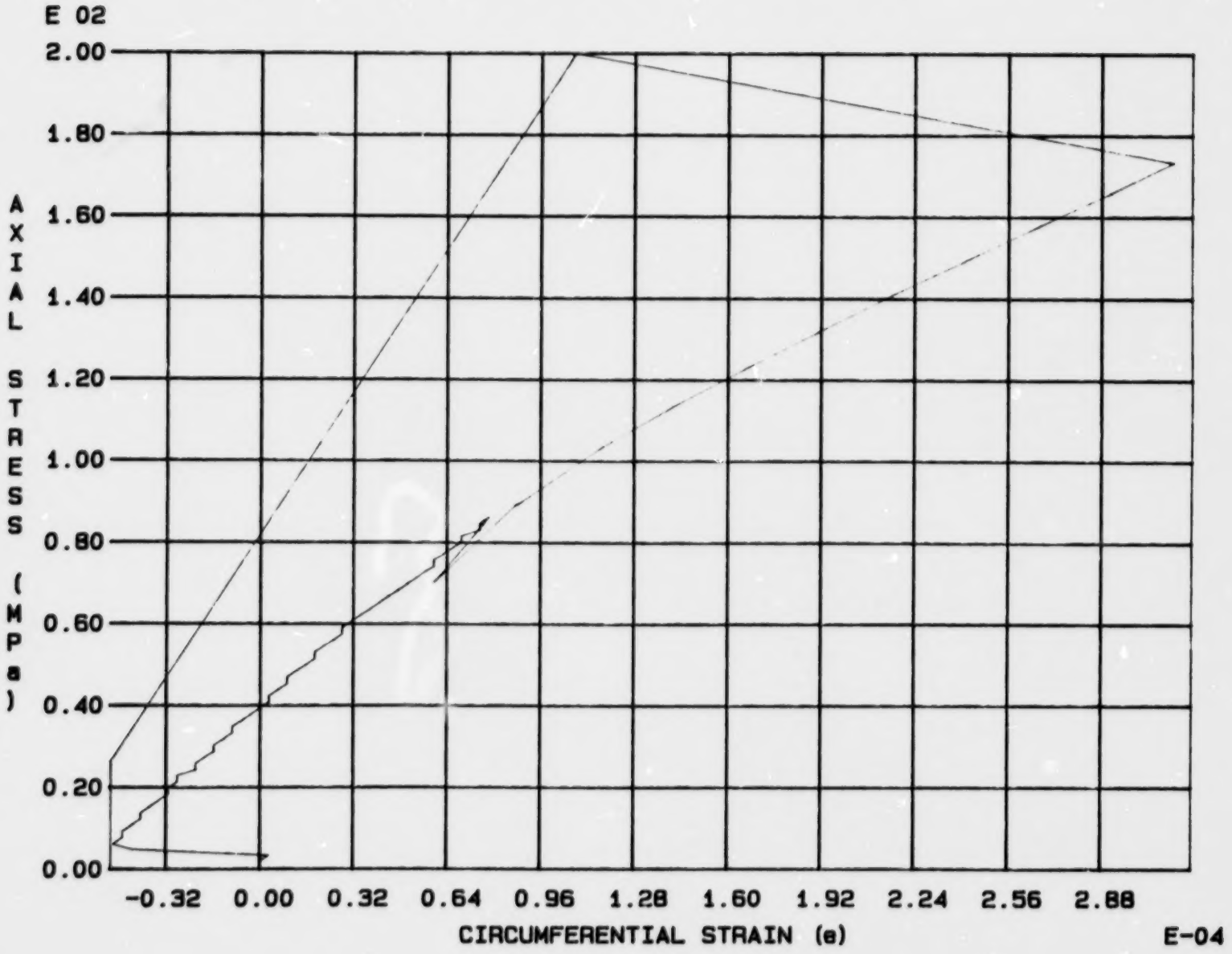

E 02
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
AXIAL STRESS (MPa)
-0.32
0.00
0.32
0.64
0.96
1.28
1.60
1.92
2.24
2.56
2.88
CIRCUMFERENTIAL STRAIN (e)
E-04

Fig. F-29 E61M

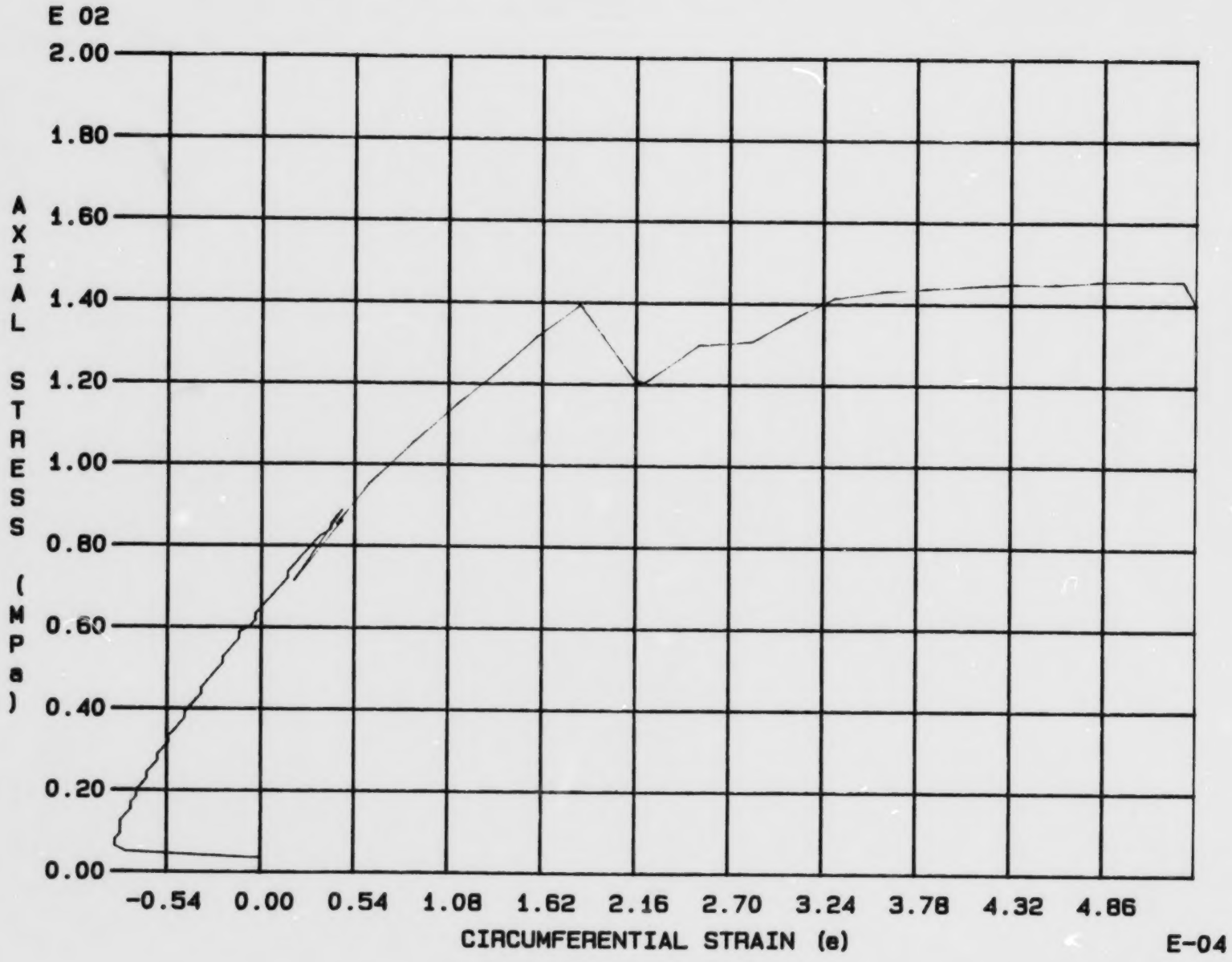

E 02
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
AXIAL STRESS (MPa)
-0.54
0.00
0.54
1.08
1.62
2.16
2.70
3.24
3.78
4.32
4.86
CIRCUMFERENTIAL STRAIN (e)
E-04

Fig. F-30 E62M

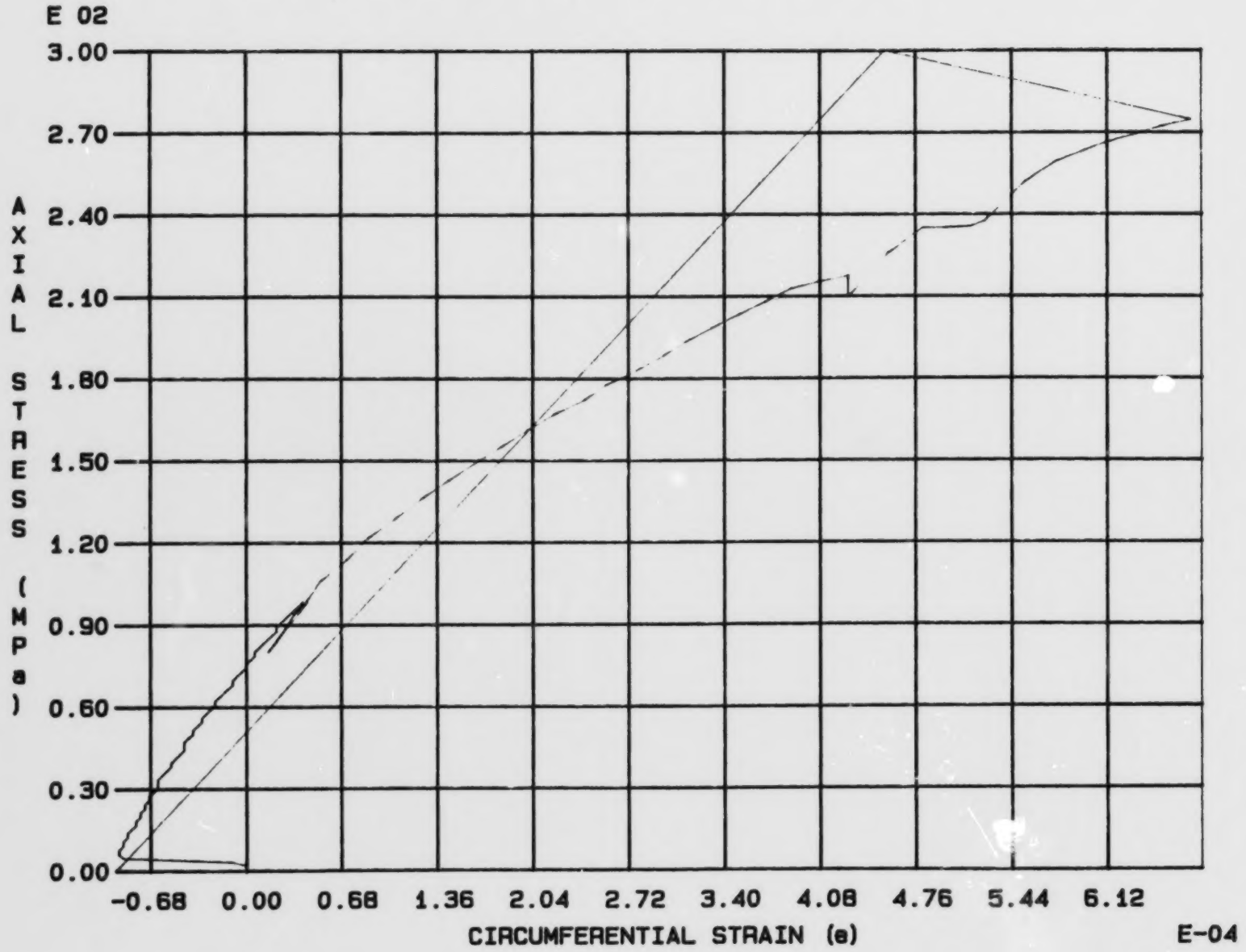

E 02
3.00
2.70
2.40
2.10
1.80
1.50
1.20
0.90
0.60
0.30
0.00
AXIAL STRESS (MPa)
-0.68
0.00
0.68
1.36
2.04
2.72
3.40
4.08
4.76
5.44
6.12
CIRCUMFERENTIAL STRAIN (e)
E-04

Fig. F-31 E63M

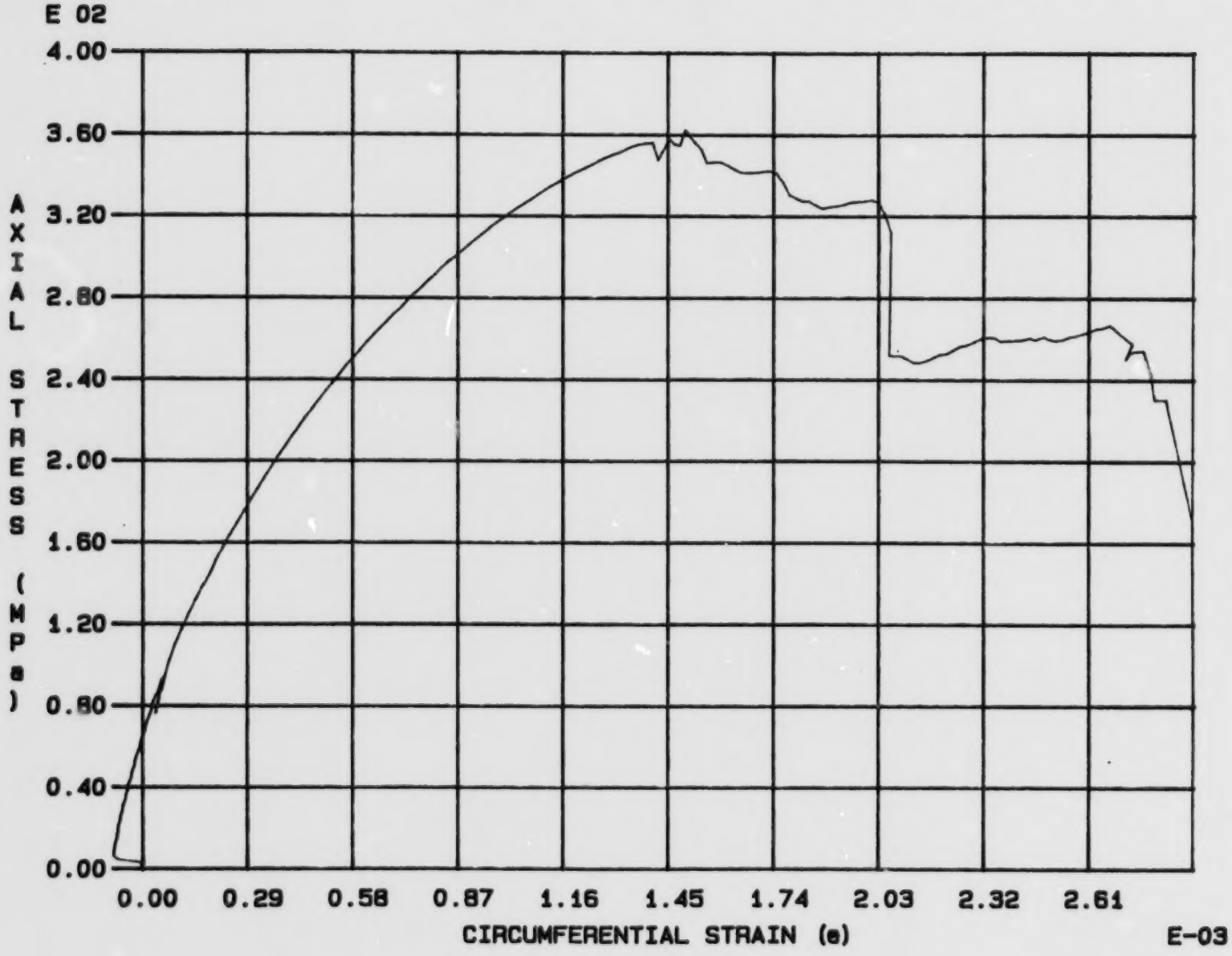

E 02
4.00
3.60
3.20
2.80
2.40
2.00
1.60
1.20
0.80
0.40
0.00
AXIAL STRESS (MPa)
0.00
0.29
0.58
0.87
1.16
1.45
1.74
2.03
2.32
2.61
CIRCUMFERENTIAL STRAIN (e)
E-03

Fig. F-32 E64M

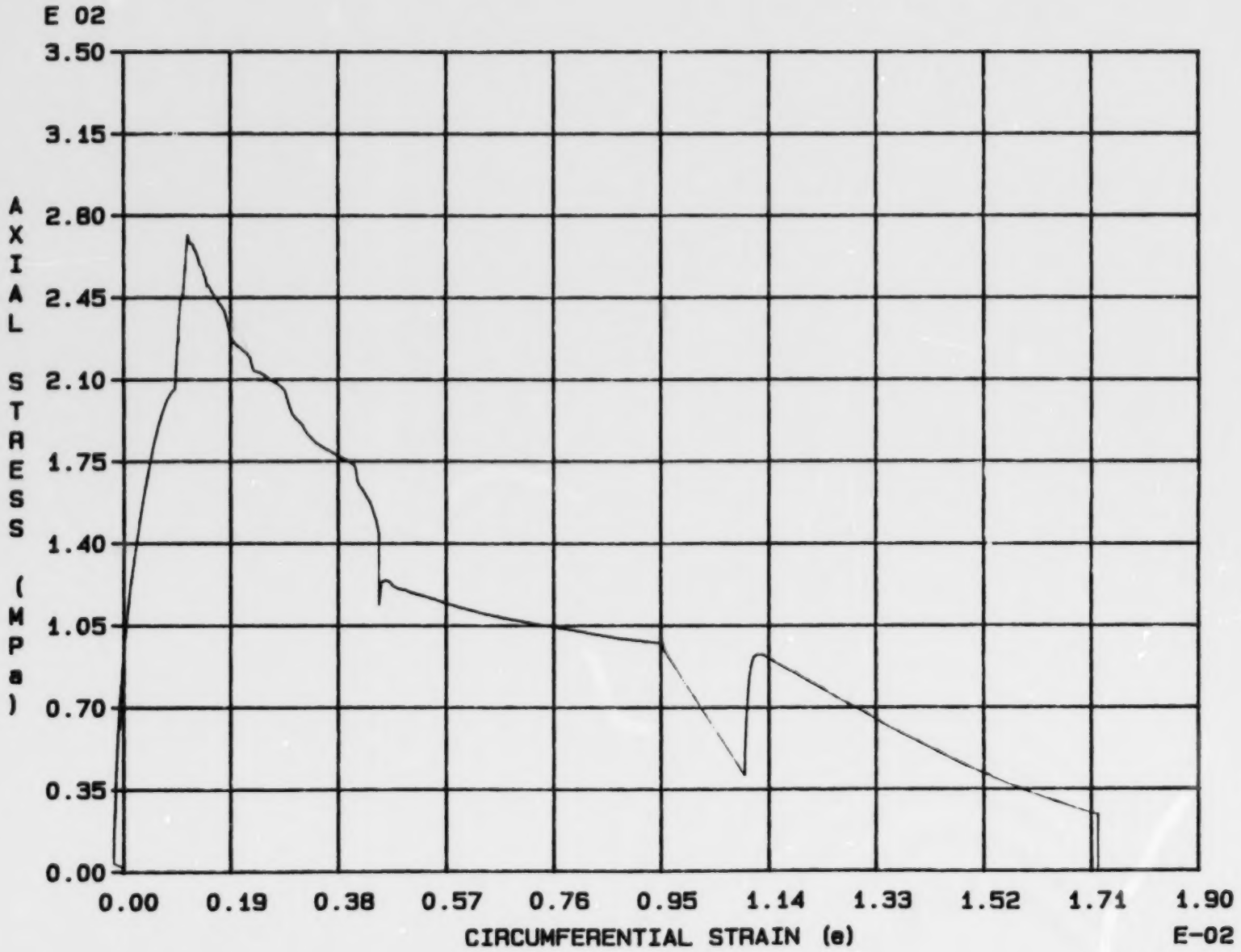

E 02
3.50
3.15
2.80
2.45
2.10
1.75
1.40
1.05
0.70
0.35
0.00
AXIAL STRESS (MPa)
0.00
0.19
0.38
0.57
0.76
0.95
1.14
1.33
1.52
1.71
1.90
CIRCUMFERENTIAL STRAIN (e)
E-02

Fig. F-33 E65M

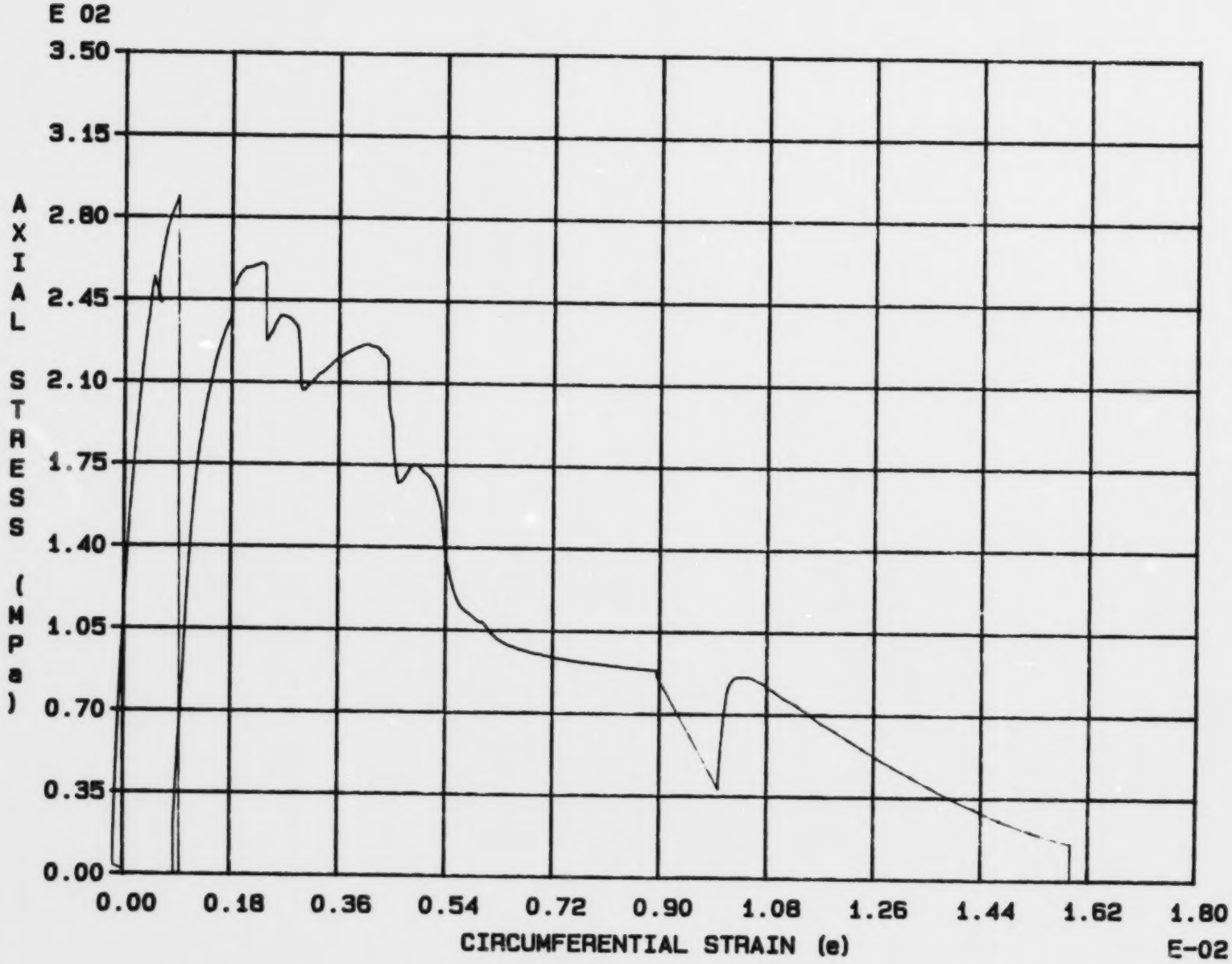

E 02
3.50
3.15
2.80
2.45
2.10
1.75
1.40
1.05
0.70
0.35
0.00
AXIAL STRESS (MPa)
0.00
0.18
0.36
0.54
0.72
0.90
1.08
1.26
1.44
1.62
1.80
CIRCUMFERENTIAL STRAIN (e)
E-02

Fig. F-34 E66M

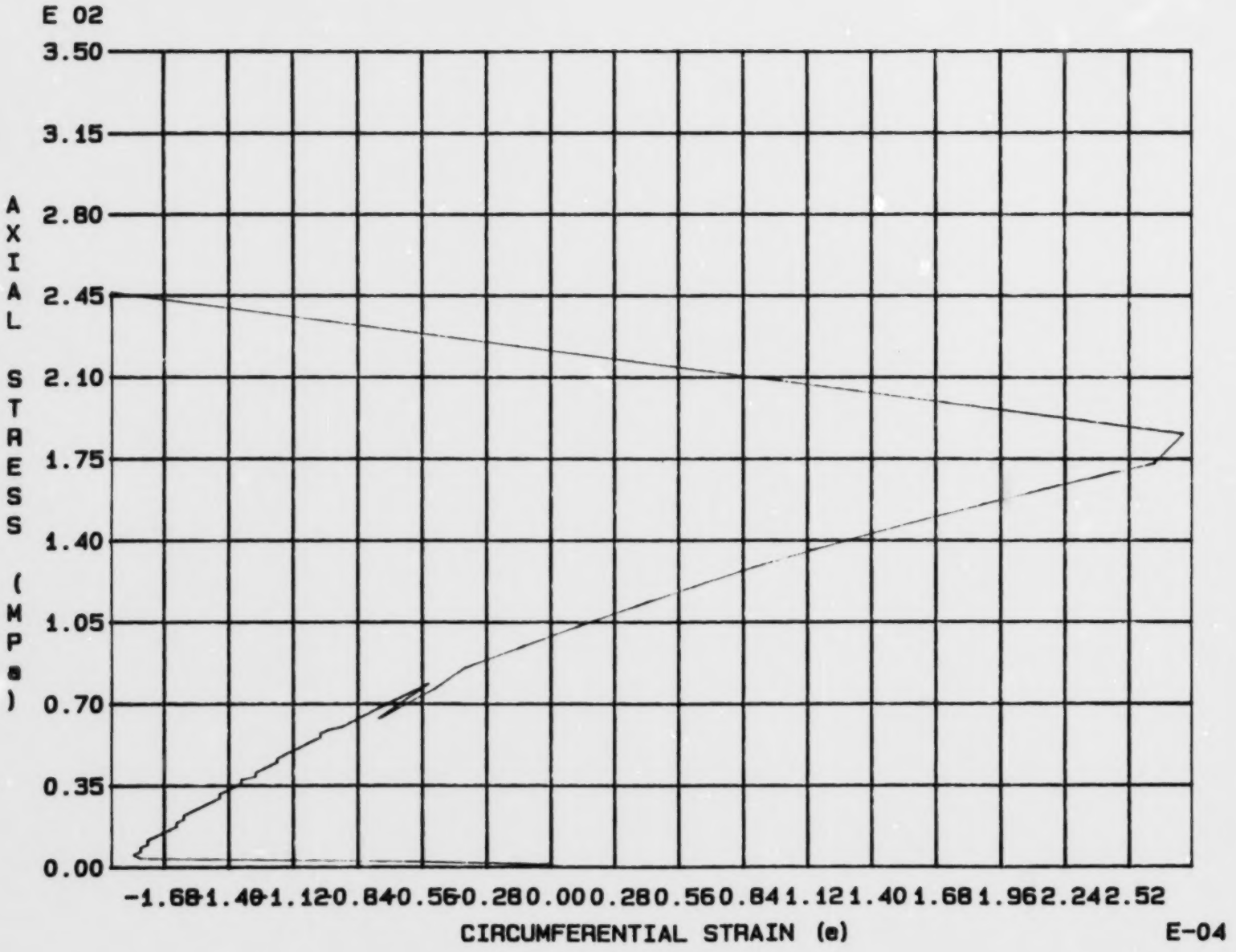

E 02
3.50
3.15
2.80
2.45
2.10
1.75
1.40
1.05
0.70
0.35
0.00
AXIAL STRESS (MPa)
-1.68 -1.40 -1.12 -0.84 -0.56 -0.28 0.00 0.28 0.56 0.84 1.12 1.40 1.68 1.96 2.24 2.52
CIRCUMFERENTIAL STRAIN (e)
E-04

Fig. F-35 E67M

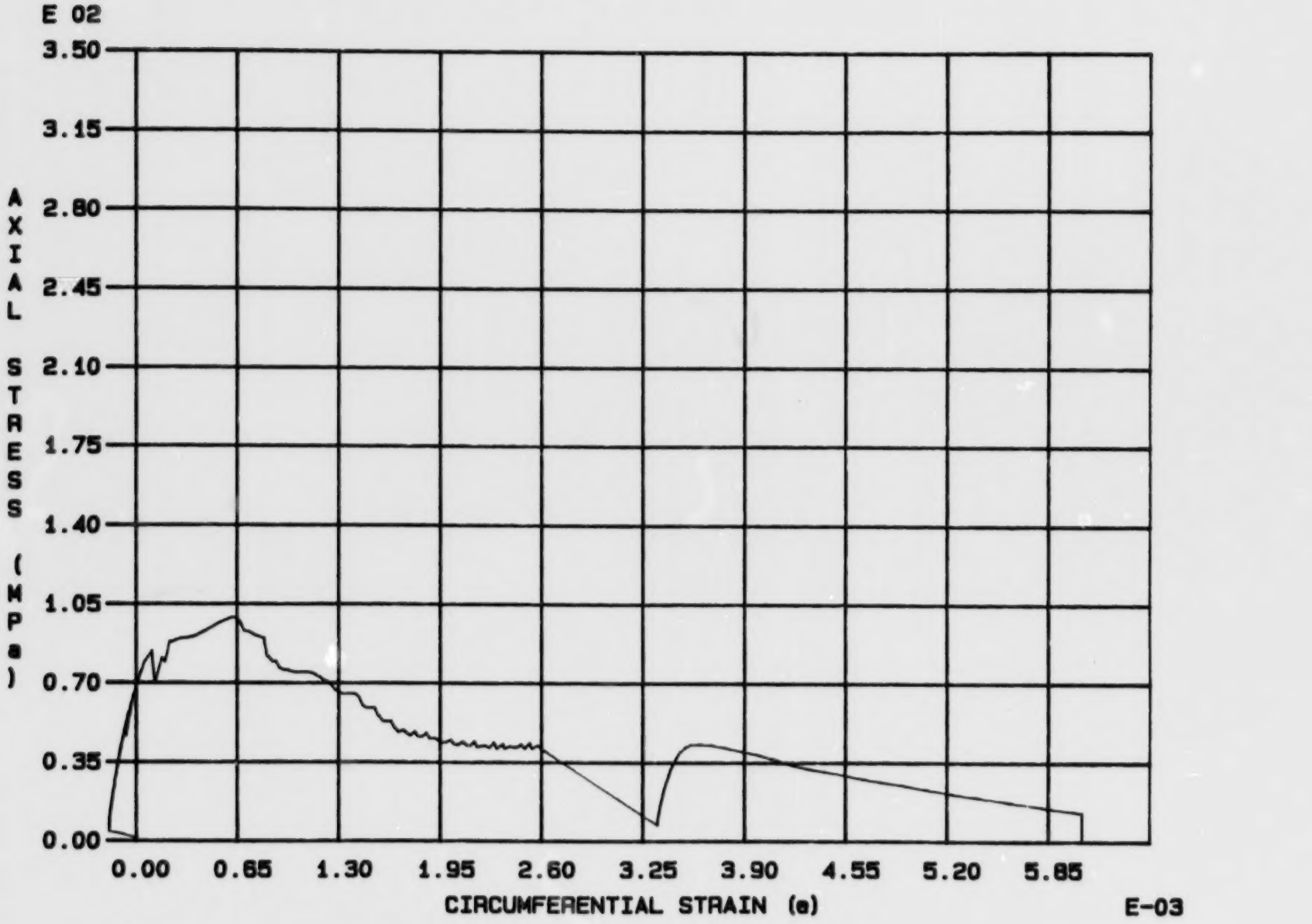

E 02
3.50
3.15
2.80
2.45
2.10
1.75
1.40
1.05
0.70
0.35
0.00
AXIAL STRESS (MPa)
0.00
0.65
1.30
1.95
2.60
3.25
3.90
4.55
5.20
5.85
CIRCUMFERENTIAL STRAIN (e)
E-03

Fig. F-36 E68M

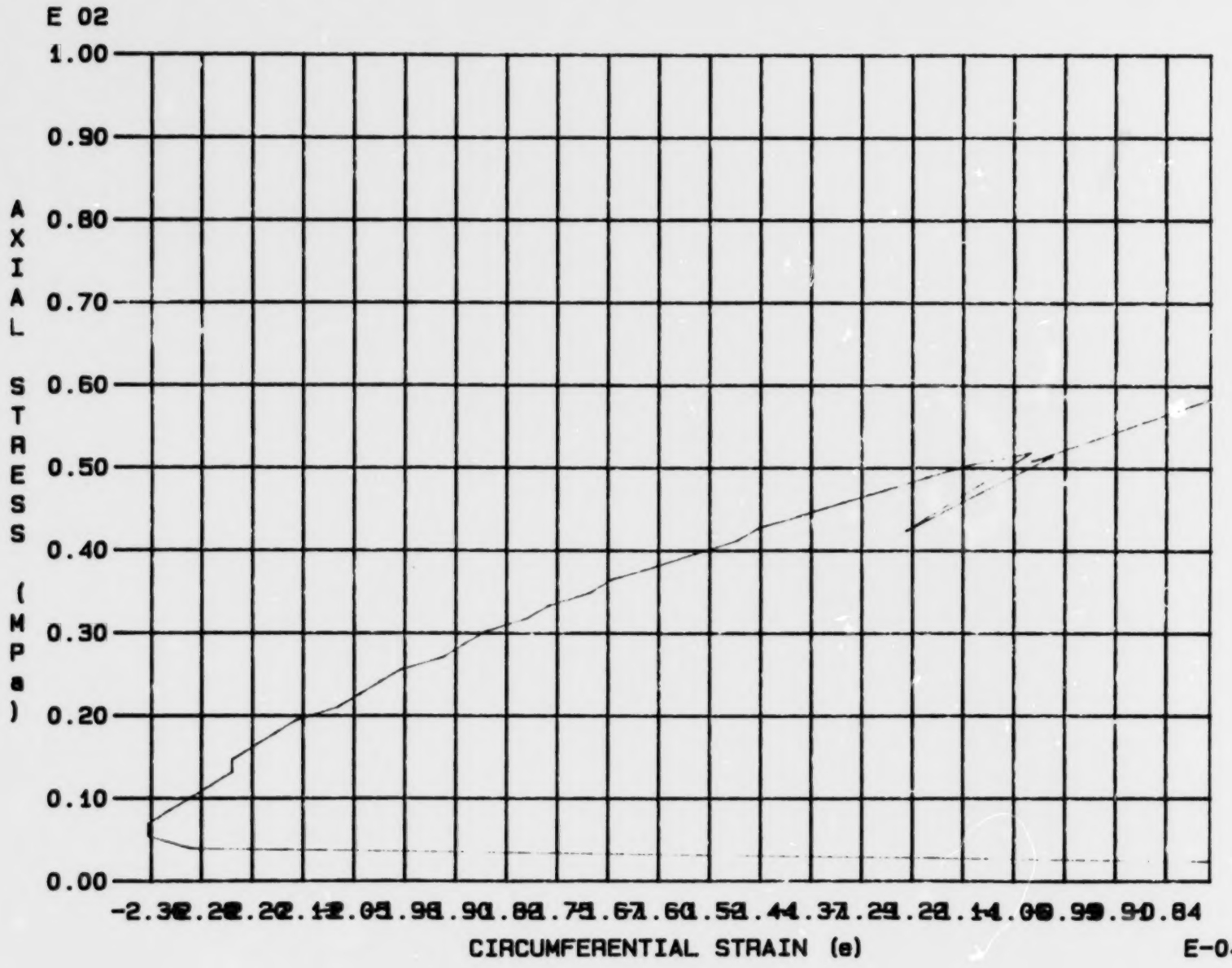

E 02
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
AXIAL STRESS (MPa)
-2.30 -2.20 -2.10 -2.05 -1.98 -1.90 -1.83 -1.75 -1.67 -1.60 -1.53 -1.44 -1.37 -1.29 -1.21 -1.14 -1.06 -0.99 -0.90 -0.84
CIRCUMFERENTIAL STRAIN (e)
E-04

Fig. F-37 E69M

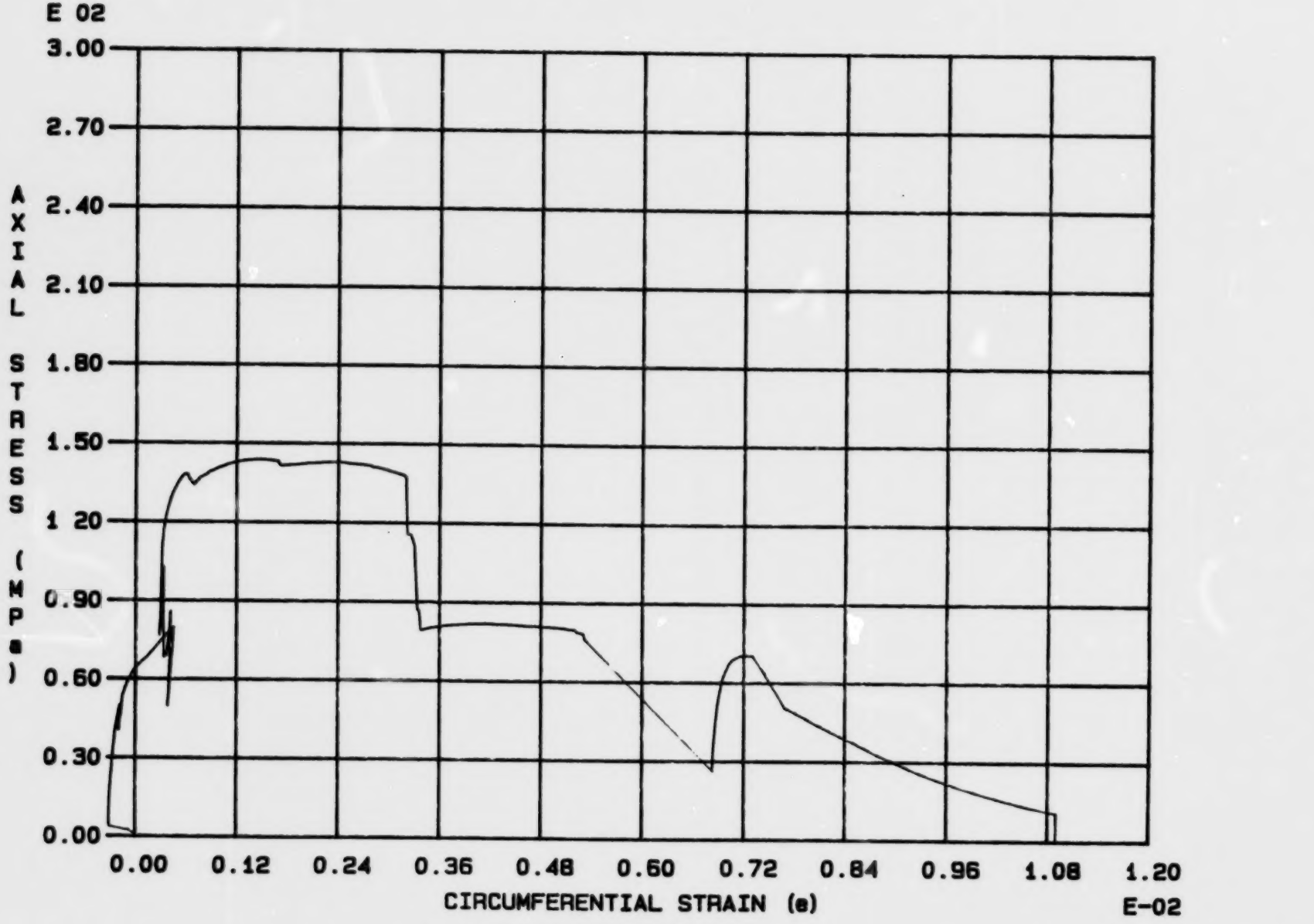

E 02
3.00
2.70
2.40
2.10
1.80
1.50
1 20
0.90
0.60
0.30
0.00
AXIAL STRESS (MPa)
0.00
0.12
0.24
0.36
0.48
0.60
0.72
0.84
0.96
1.08
1.20
CIRCUMFERENTIAL STRAIN (e)
E-02

Fig. F-38 E70M

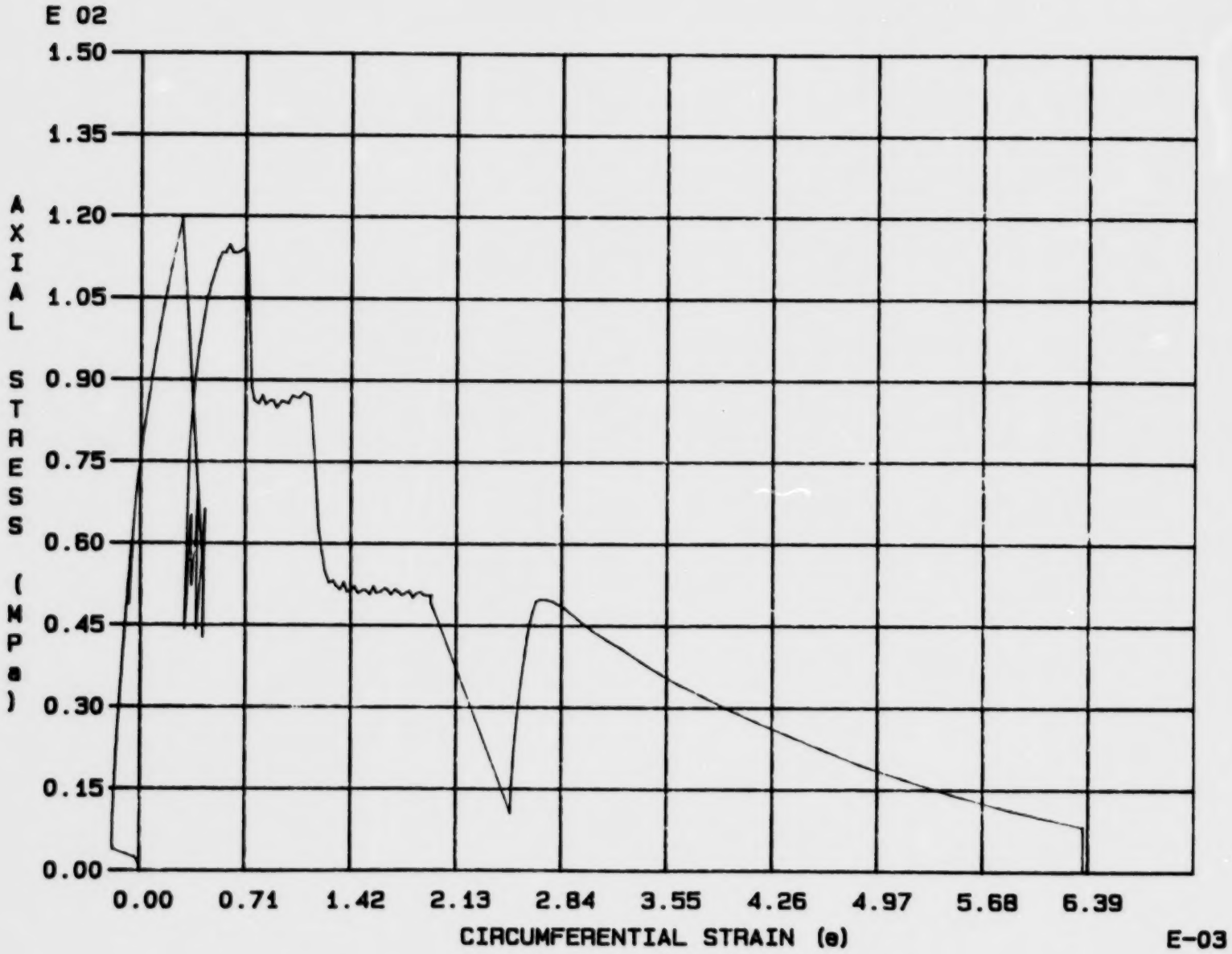

E 02
1.50
1.35
1.20
1.05
0.90
0.75
0.60
0.45
0.30
0.15
0.00
AXIAL STRESS (MPa)
0.00
0.71
1.42
2.13
2.84
3.55
4.26
4.97
5.68
6.39
CIRCUMFERENTIAL STRAIN (e)
E-03

Fig. F-39 E71M

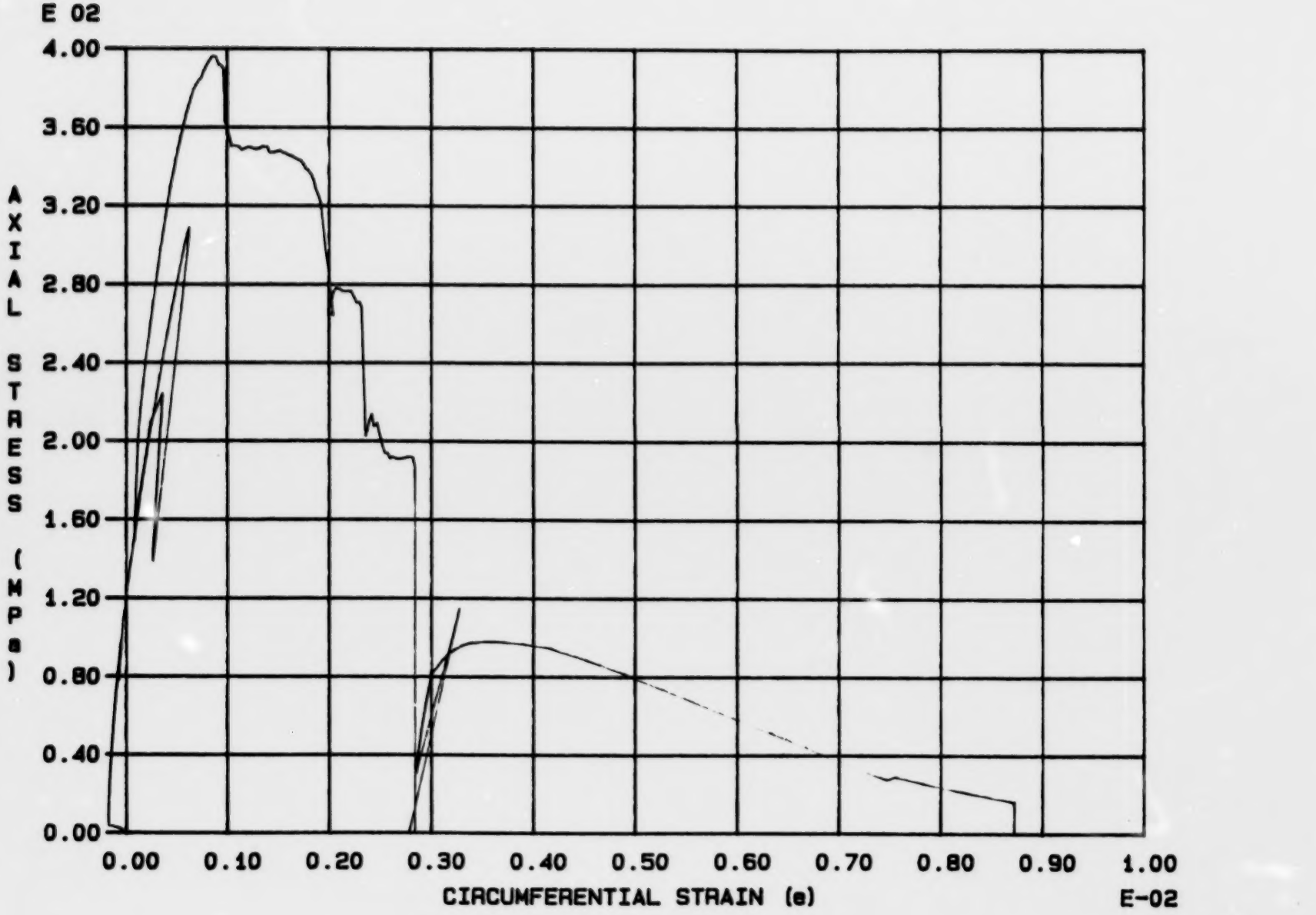

E 02
4.00
3.60
3.20
2.80
2.40
2.00
1.60
1.20
0.80
0.40
0.00
AXIAL STRESS (MPa)
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
CIRCUMFERENTIAL STRAIN (e)
E-02

Fig. F-40 E92M

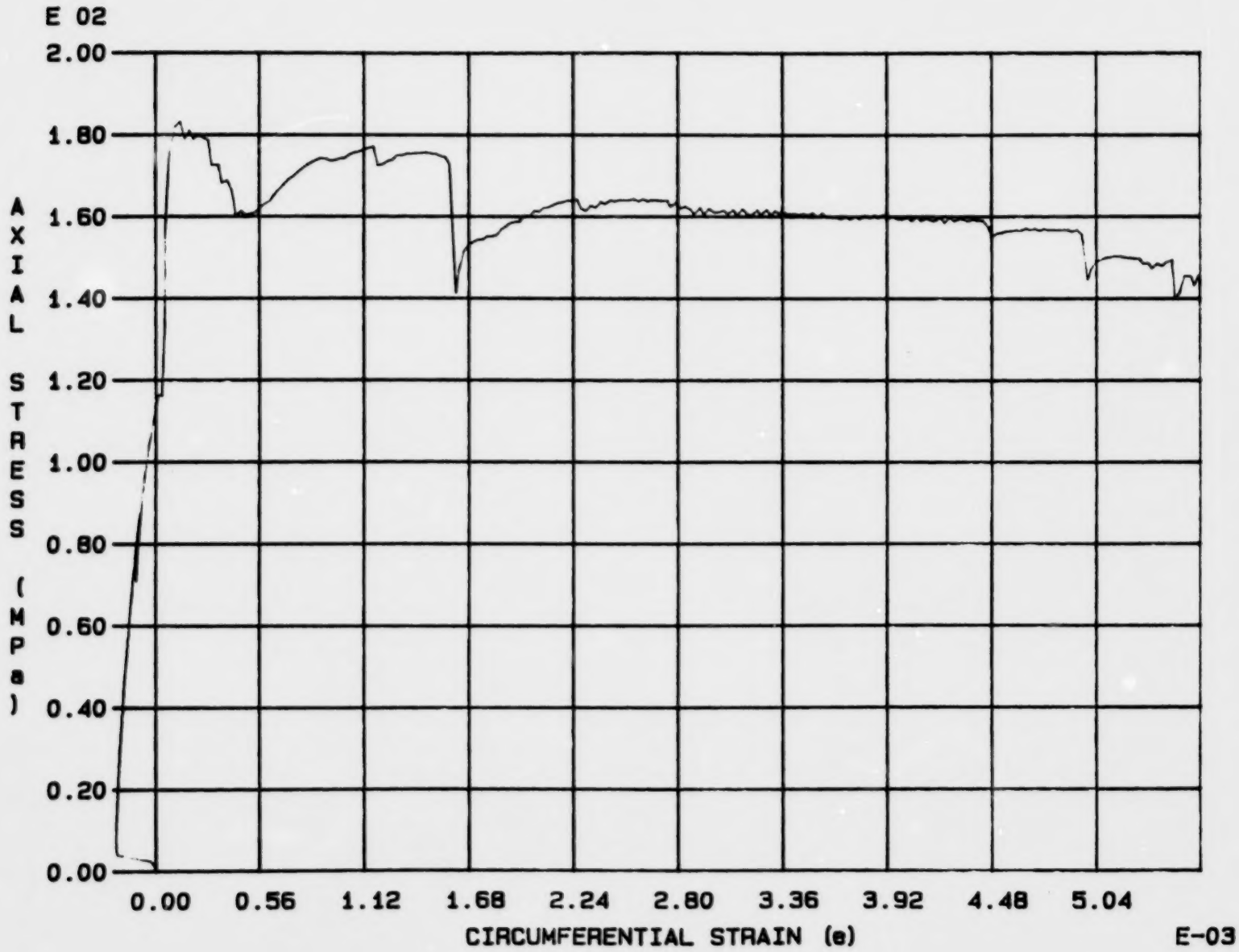

E 02
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
AXIAL STRESS (MPa)
0.00
0.56
1.12
1.68
2.24
2.80
3.36
3.92
4.48
5.04
CIRCUMFERENTIAL STRAIN (e)
E-03

Fig. F-41 E93M

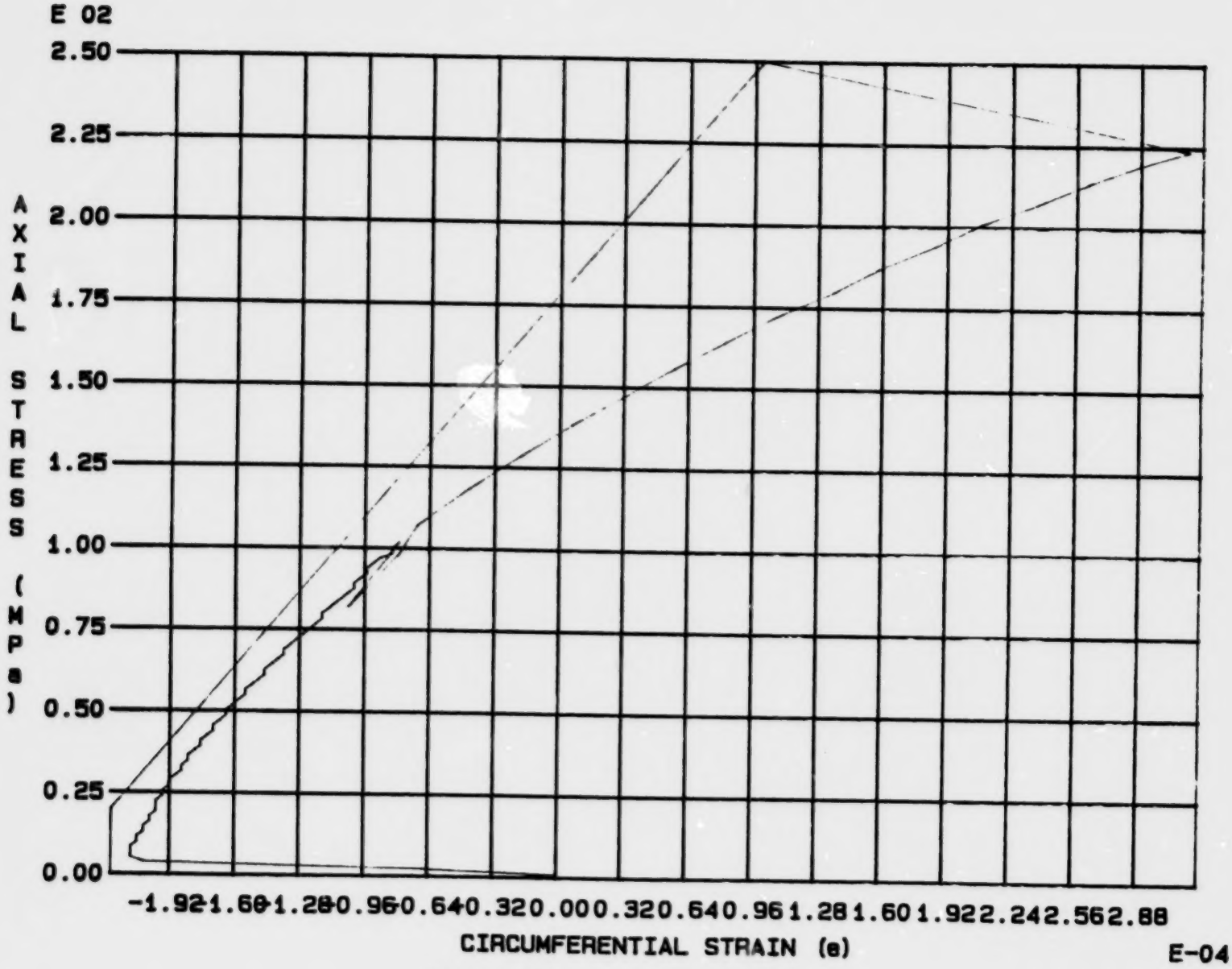

E 02
2.50
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
AXIAL STRESS (MPa)
-1.92 -1.60 -1.28 -0.96 -0.64 -0.32 0.00 0.32 0.64 0.96 1.28 1.60 1.92 2.24 2.56 2.88
CIRCUMFERENTIAL STRAIN (e)
E-04

Fig. F-42 E94M

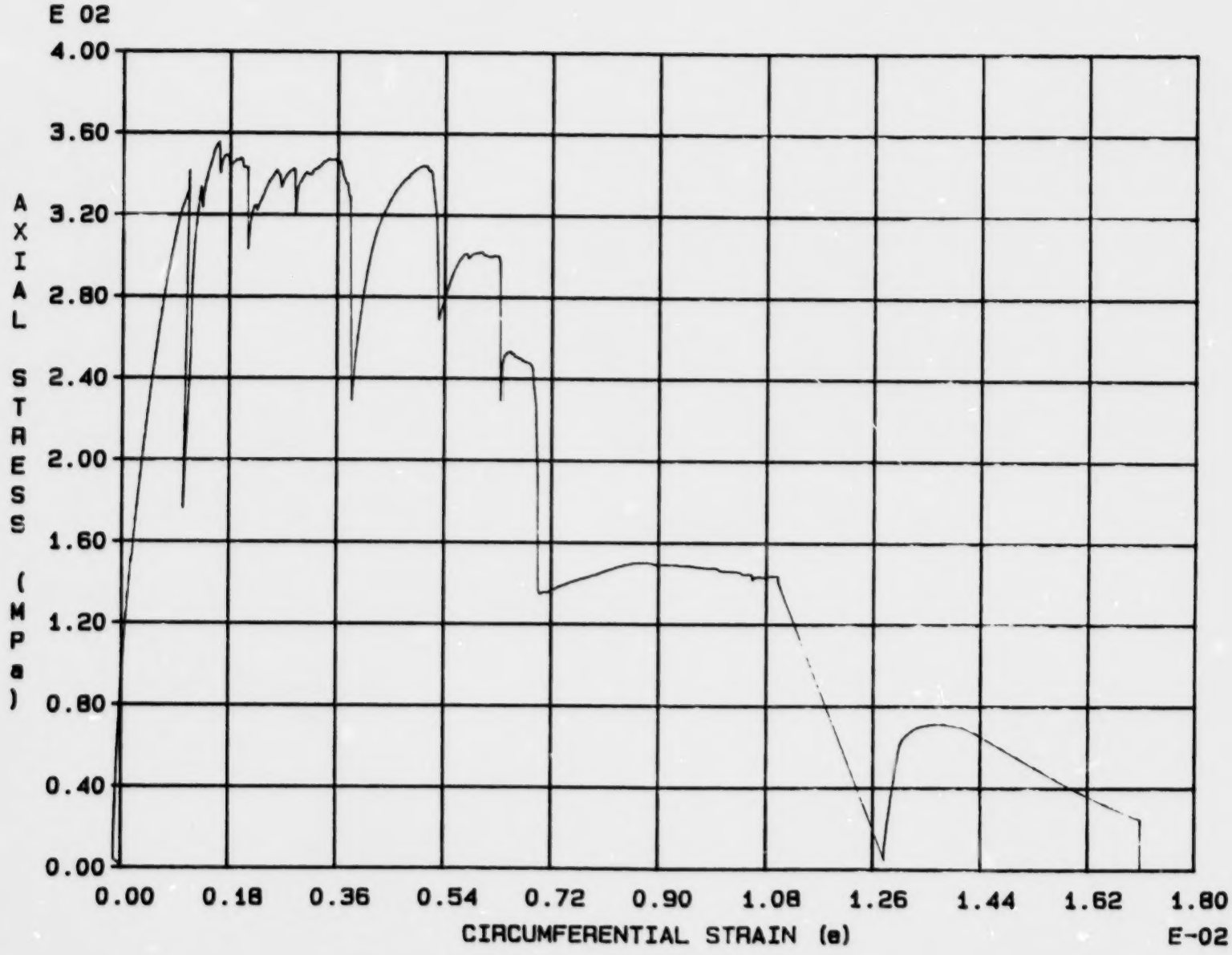

E 02
4.00
3.60
3.20
2.80
2.40
2.00
1.60
1.20
0.80
0.40
0.00
AXIAL STRESS (MPa)
0.00
0.18
0.36
0.54
0.72
0.90
1.08
1.26
1.44
1.62
1.80
CIRCUMFERENTIAL STRAIN (e)
E-02

Fig. F-43 E95M

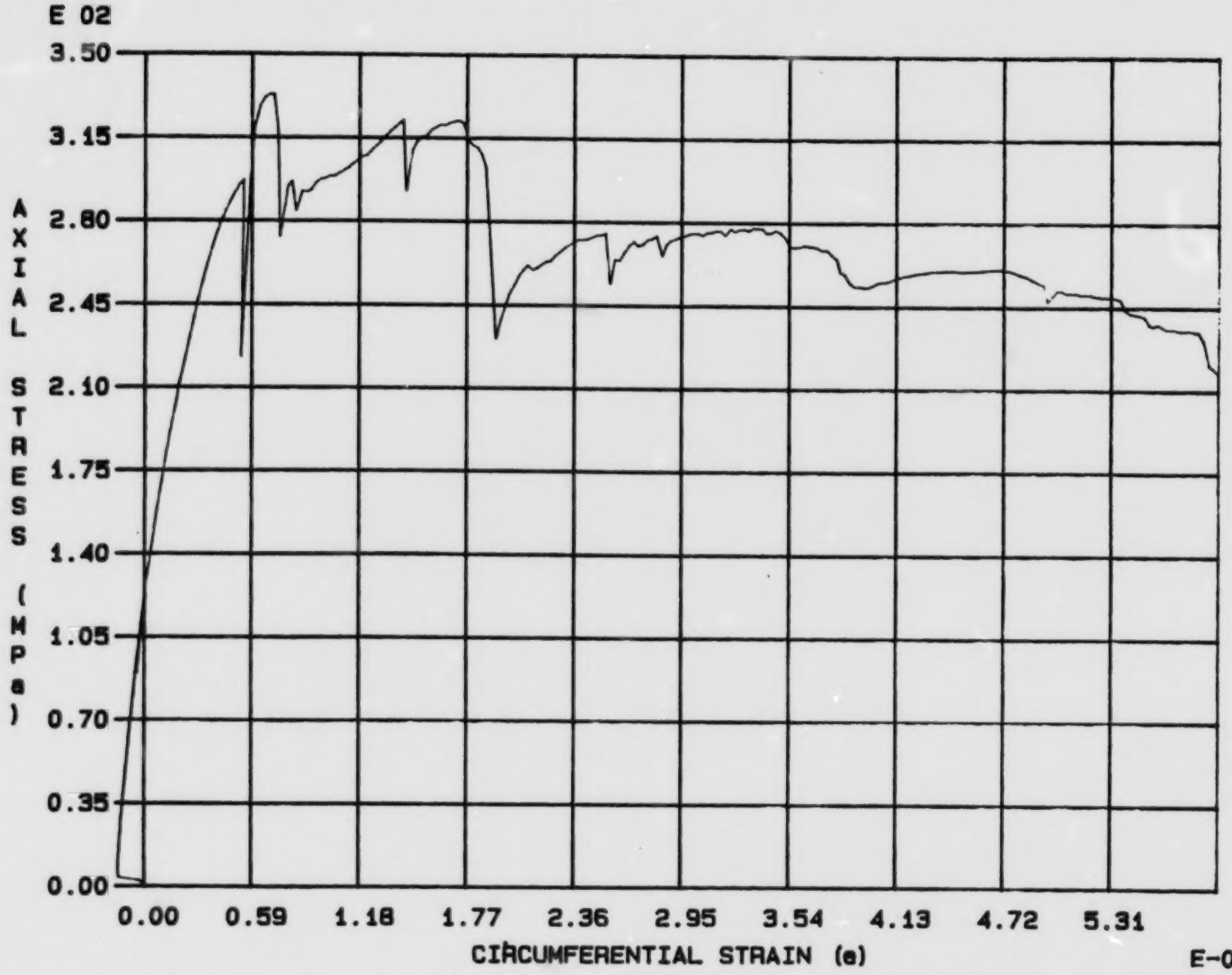

E 02
3.50
3.15
2.80
2.45
2.10
1.75
1.40
1.05
0.70
0.35
0.00
AXIAL STRESS (MPa)
0.00
0.59
1.18
1.77
2.36
2.95
3.54
4.13
4.72
5.31
CIRCUMFERENTIAL STRAIN (e)
E-03

Fig. F-44 E96M

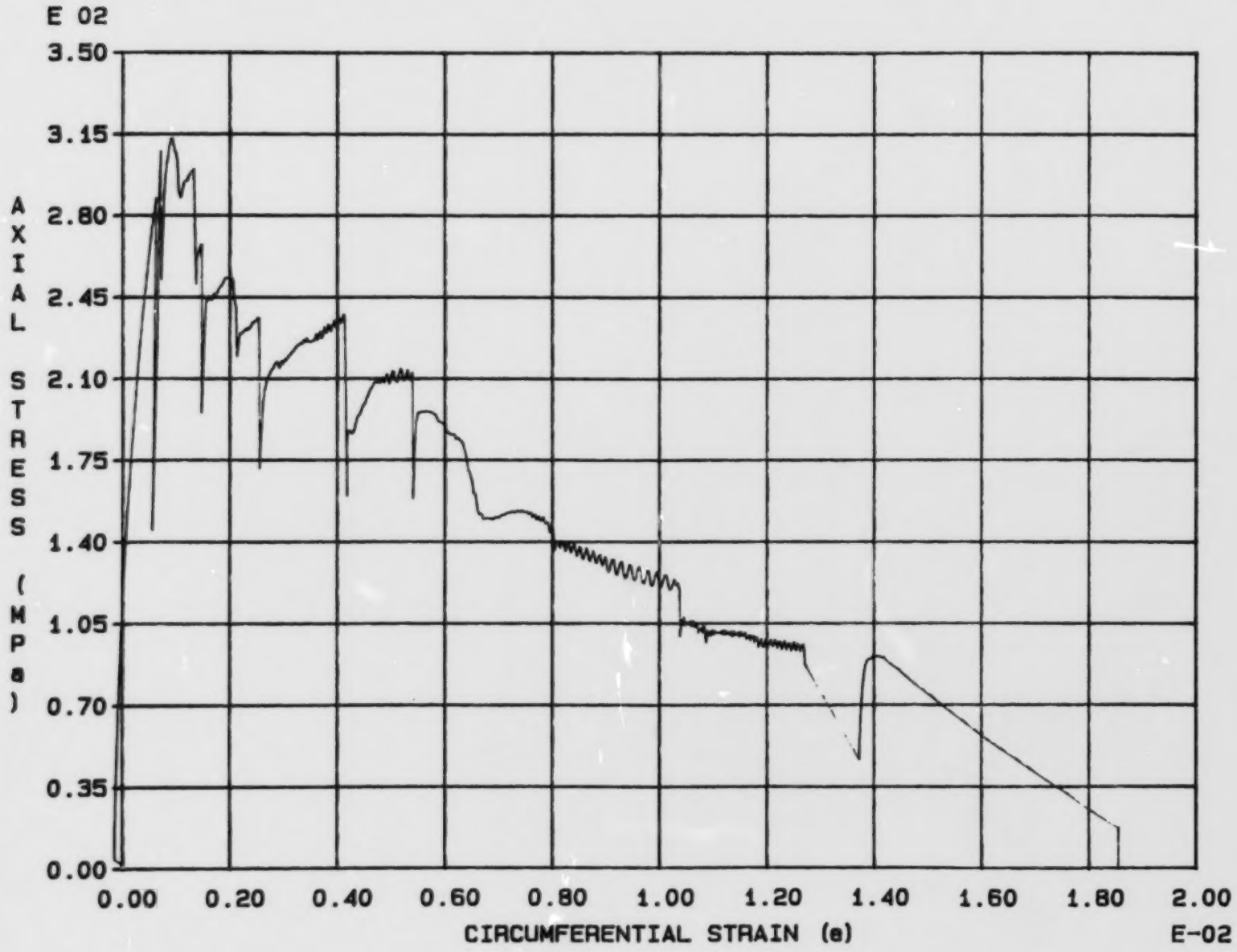

E 02
3.50
3.15
2.80
2.45
2.10
1.75
1.40
1.05
0.70
0.35
0.00
AXIAL STRESS (MPa)
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
1.60
1.80
2.00
CIRCUMFERENTIAL STRAIN (e)
E-02

Fig. F-45 E97M

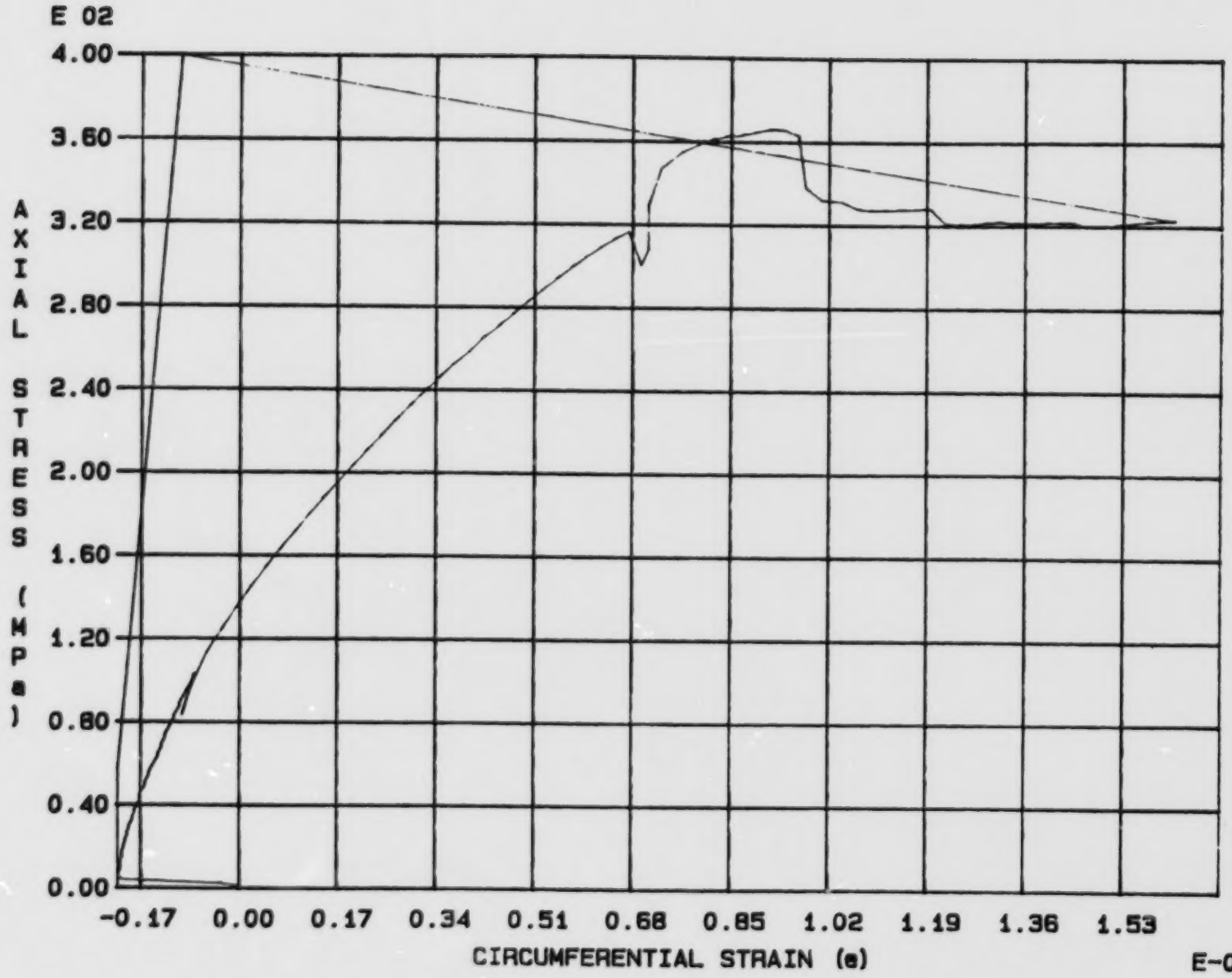

E 02
4.00
3.60
3.20
2.80
2.40
2.00
1.60
1.20
0.80
0.40
0.00
AXIAL STRESS (MPa)
-0.17
0.00
0.17
0.34
0.51
0.68
0.85
1.02
1.19
1.36
1.53
CIRCUMFERENTIAL STRAIN (e)
E-03

Fig. F-46 E98M

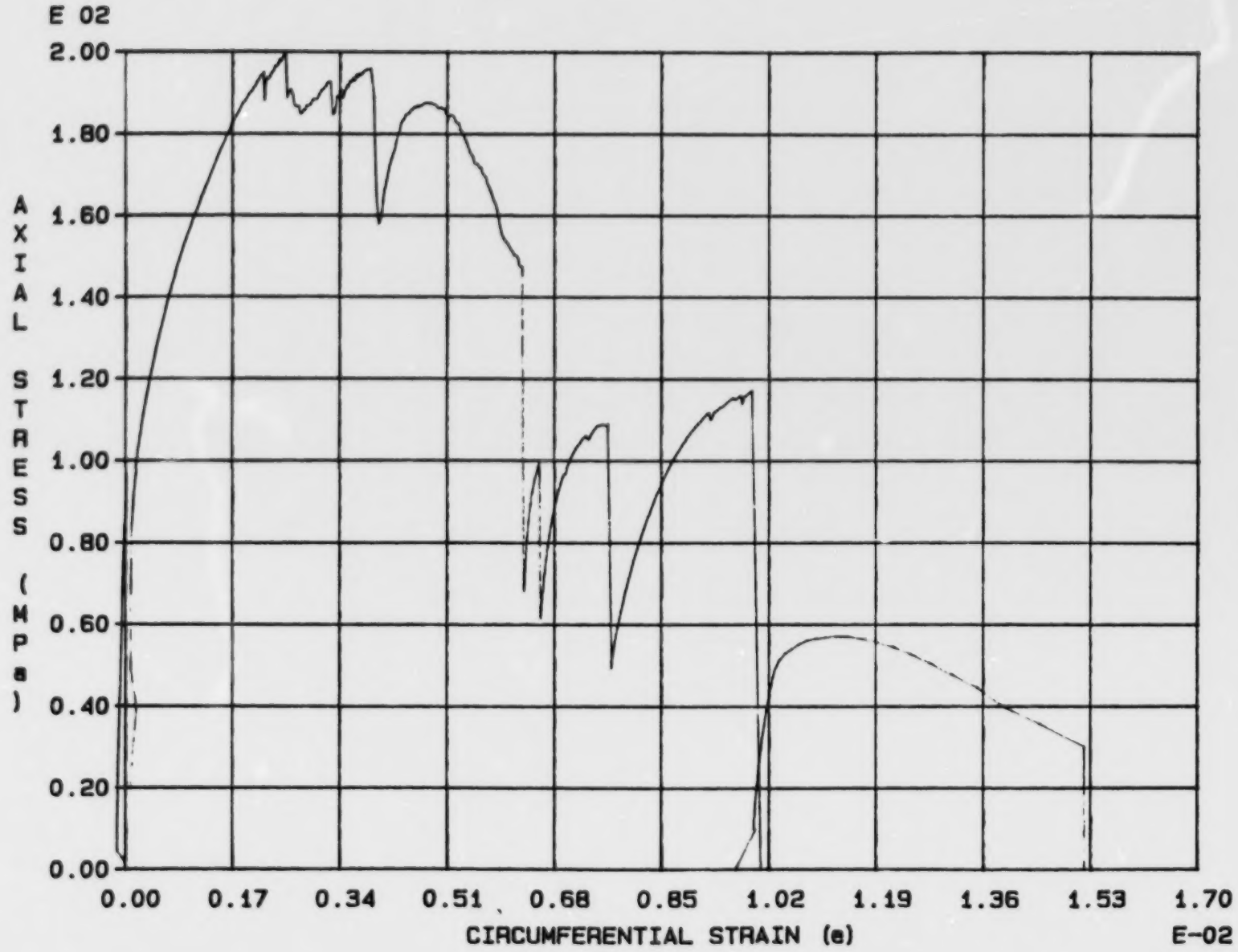

E 02
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
AXIAL STRESS (MPa)
0.00
0.17
0.34
0.51
0.68
0.85
1.02
1.19
1.36
1.53
1.70
CIRCUMFERENTIAL STRAIN (e)
E-02

Fig. F-47 E99M

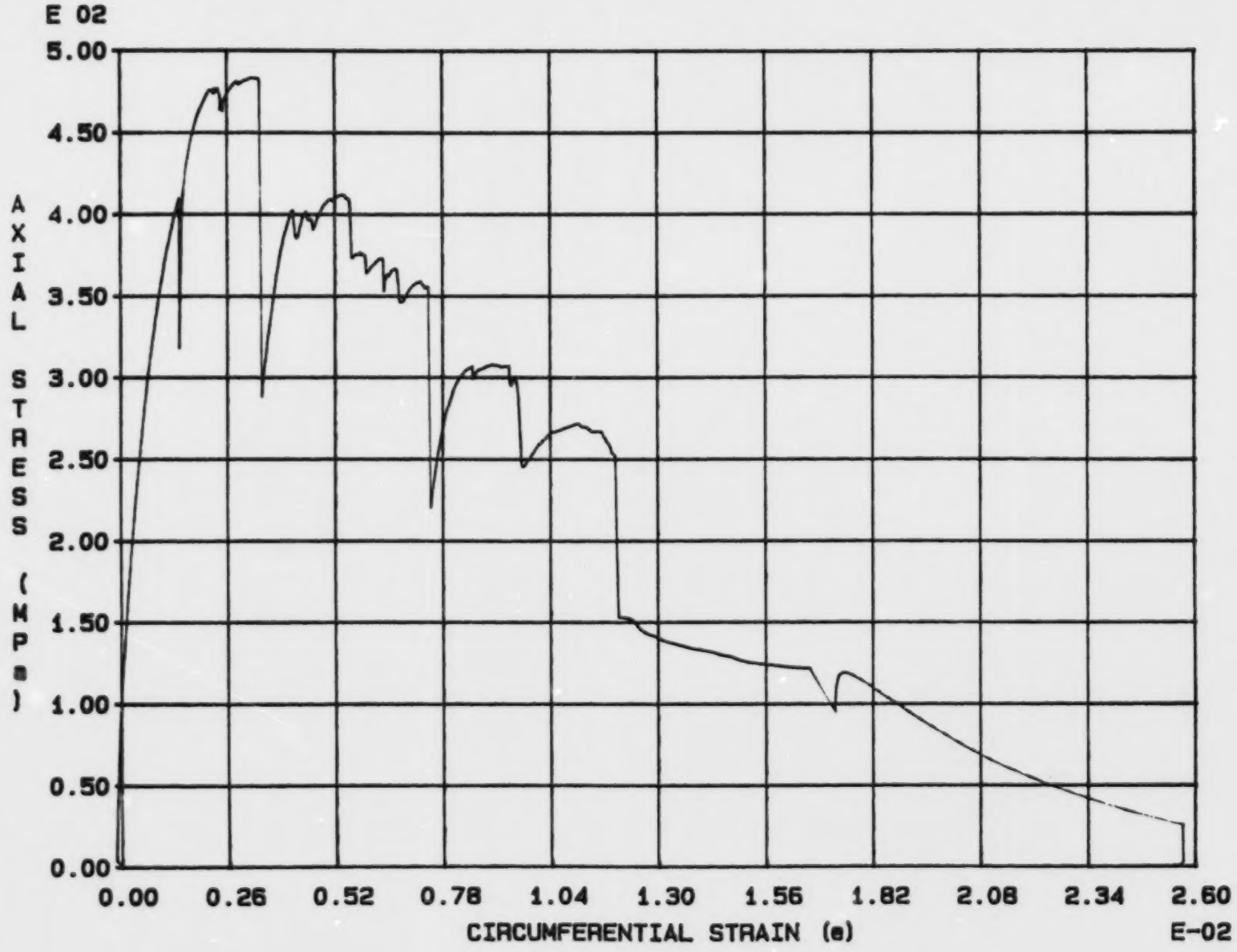


Fig. F-48 E100M

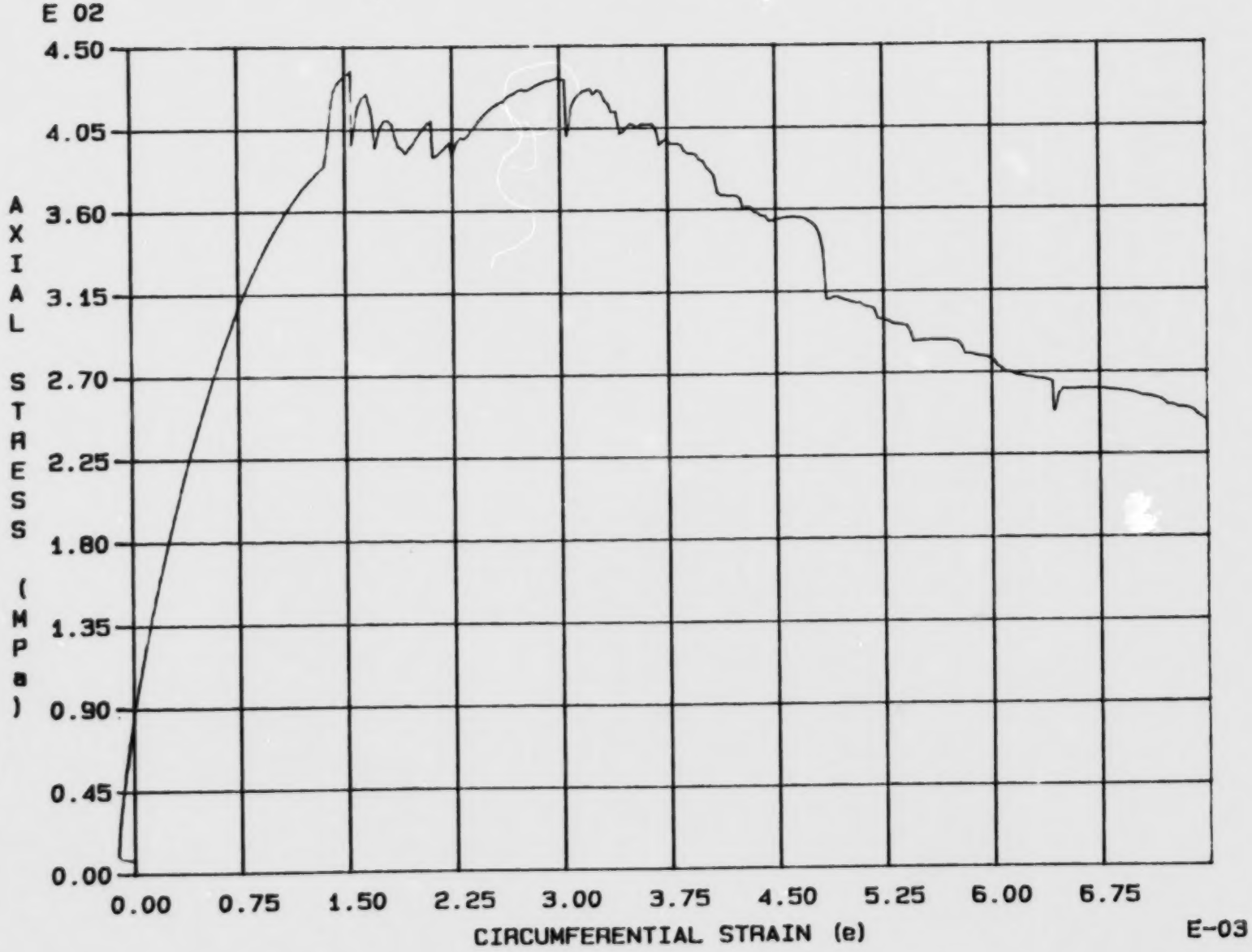


Fig. F-49 E101M

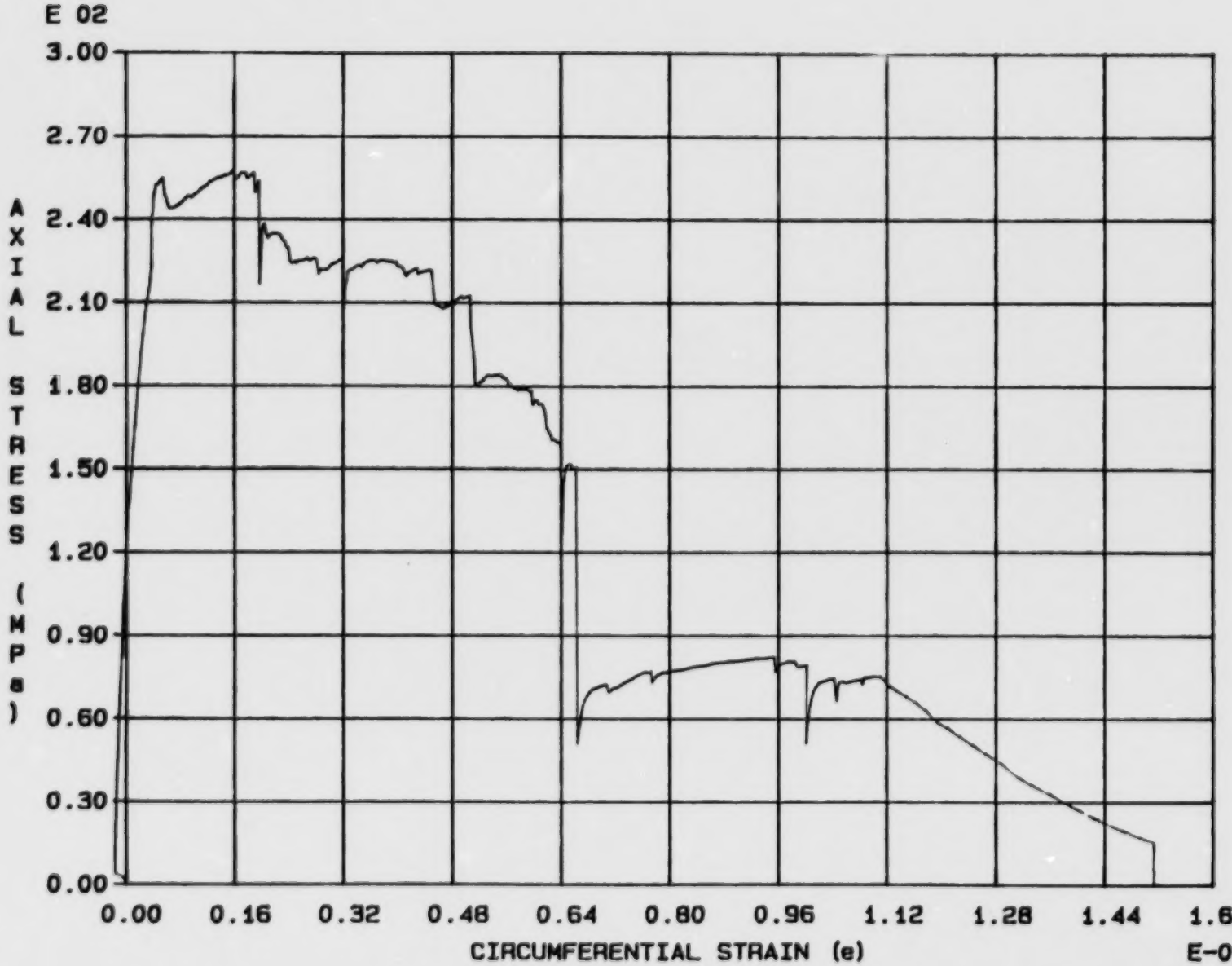


Fig. F-50 E102M

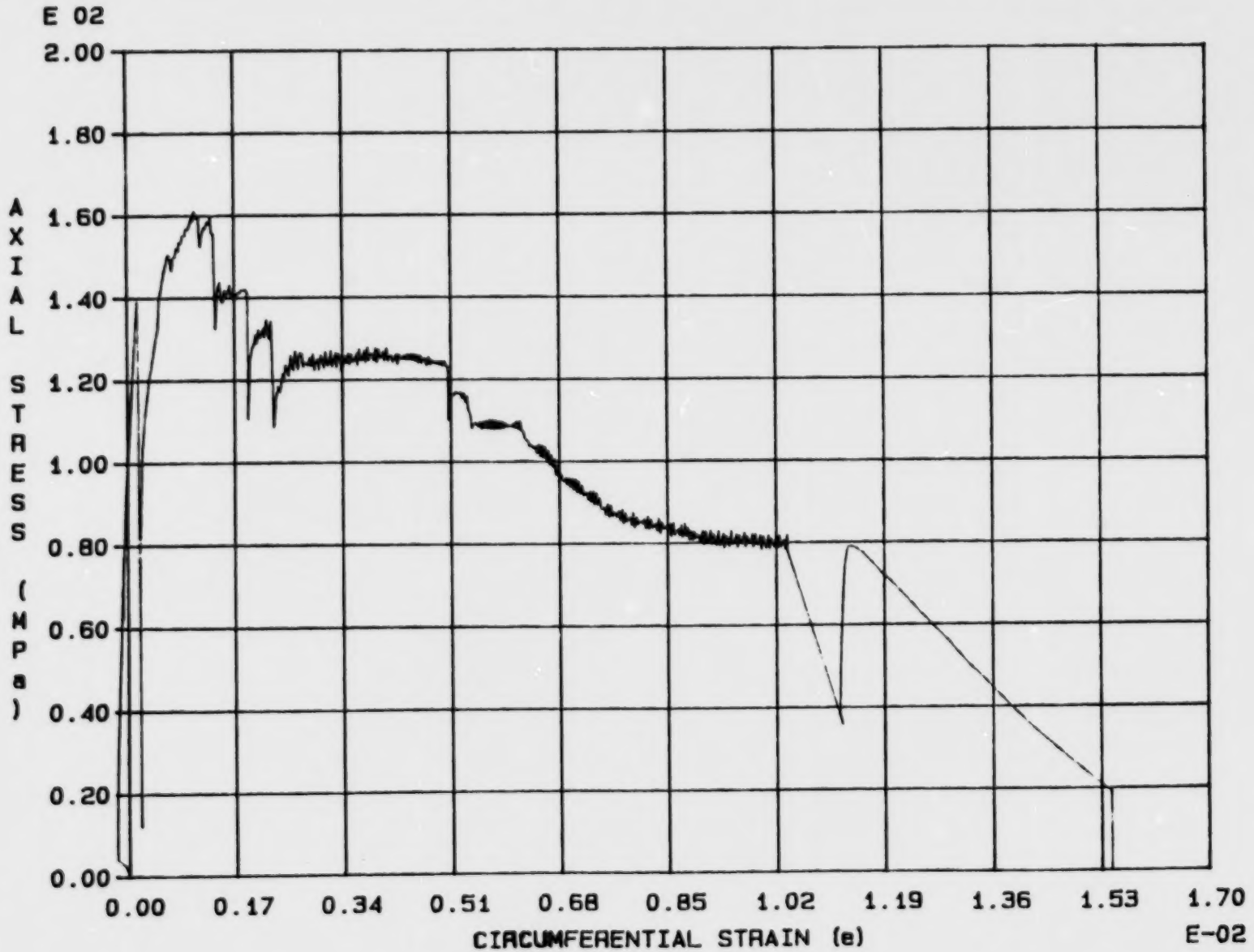


Fig. F-51 E119M

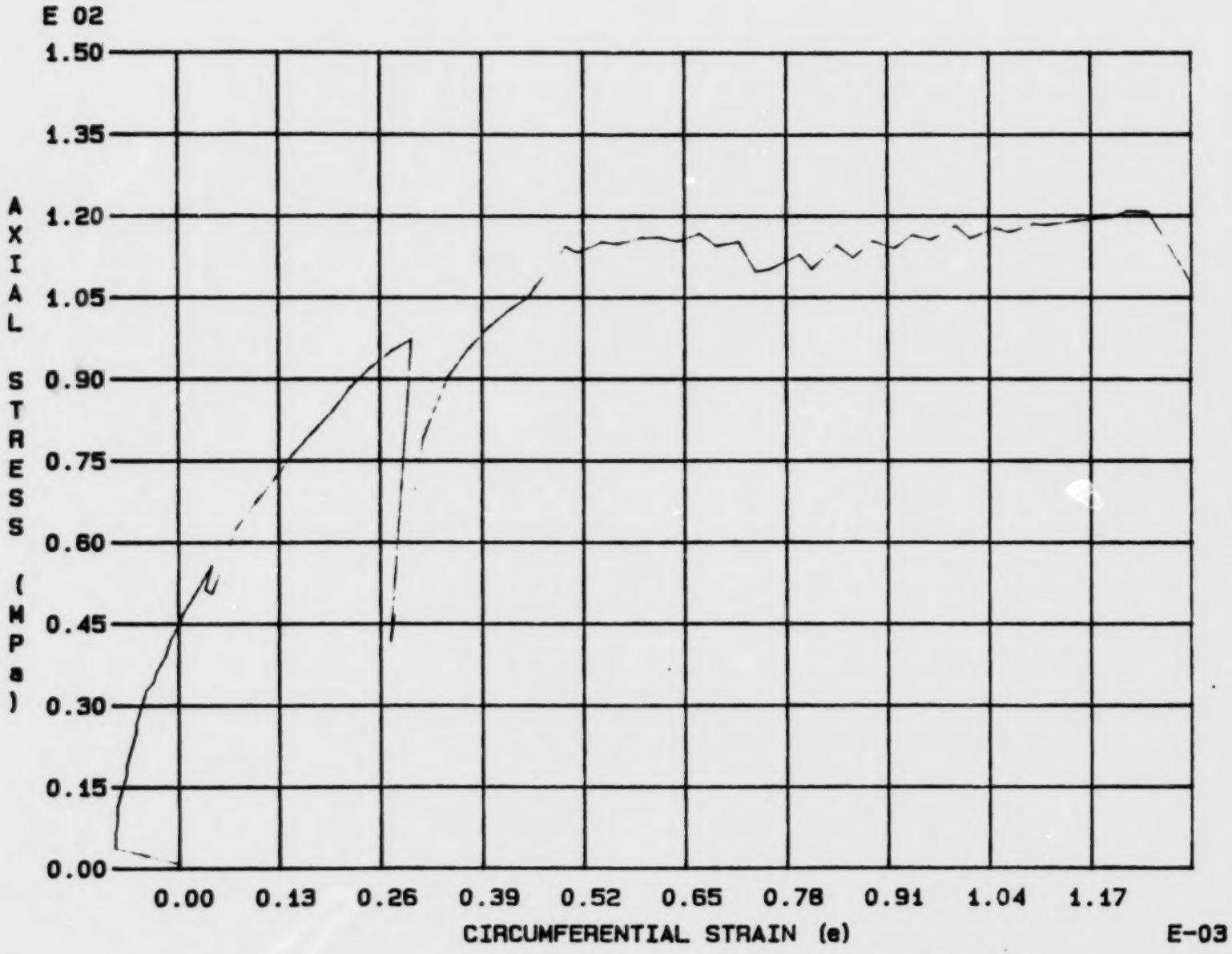


Fig. F-52 E120M

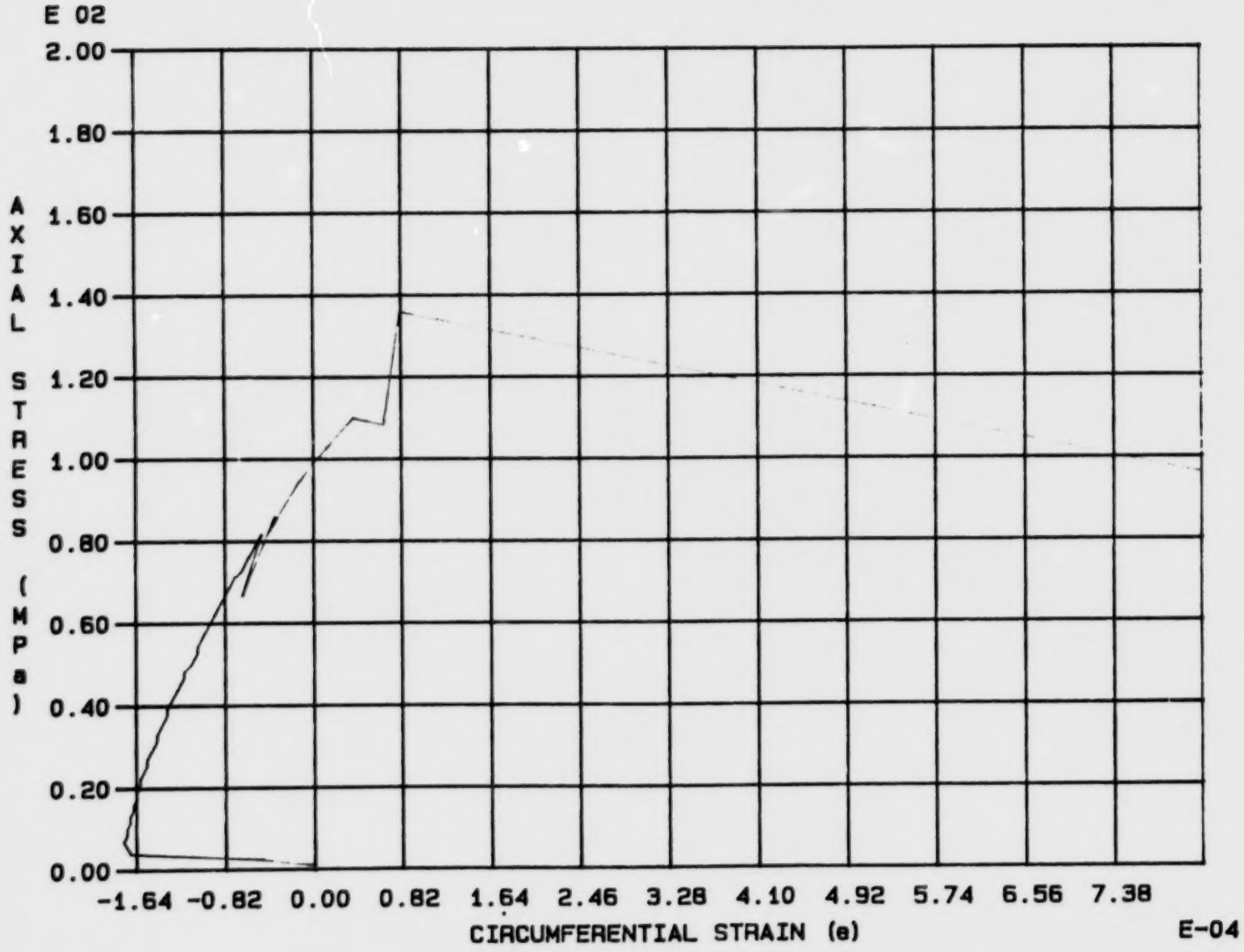


Fig. F-53 E121M

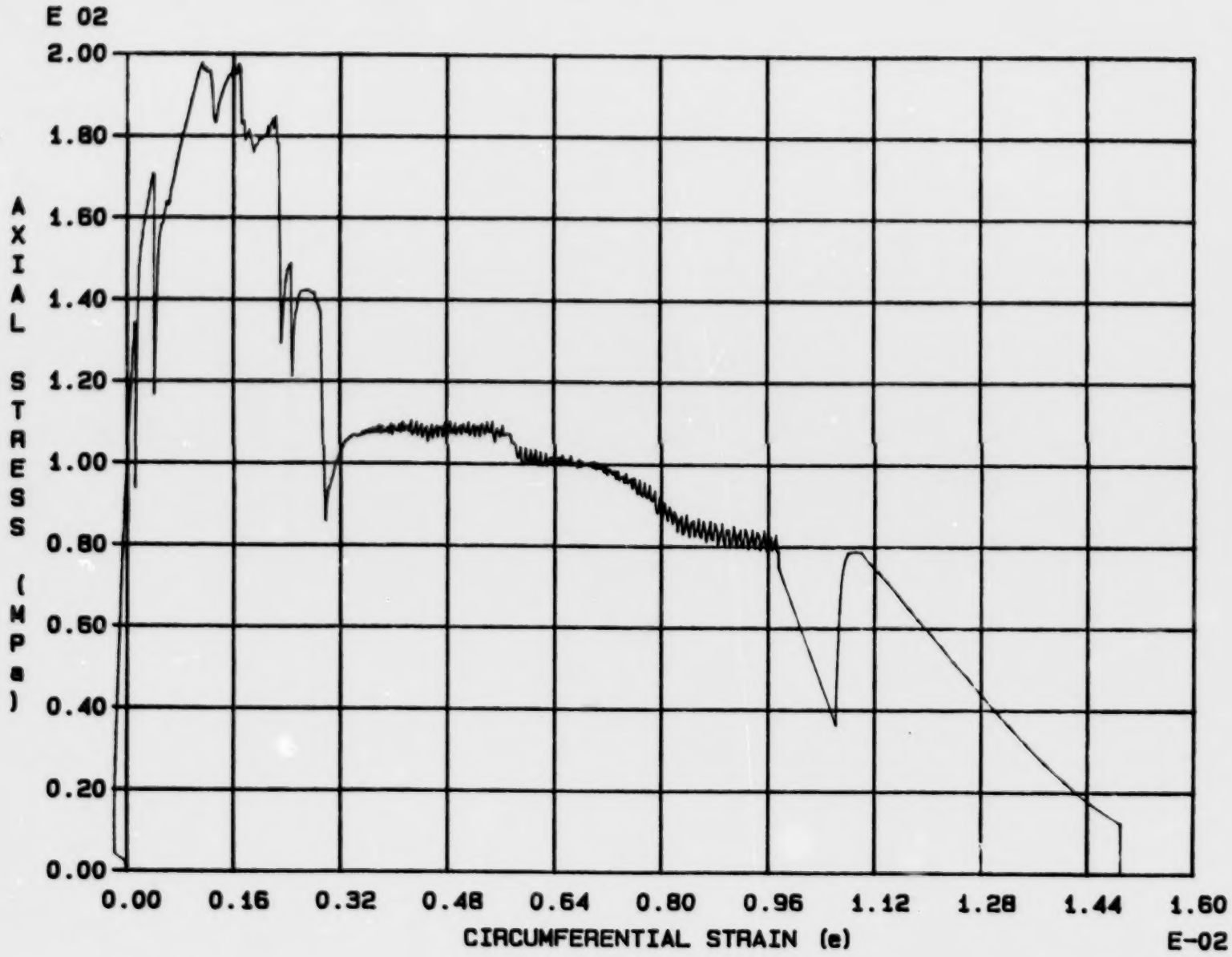


Fig. F-54 E122M

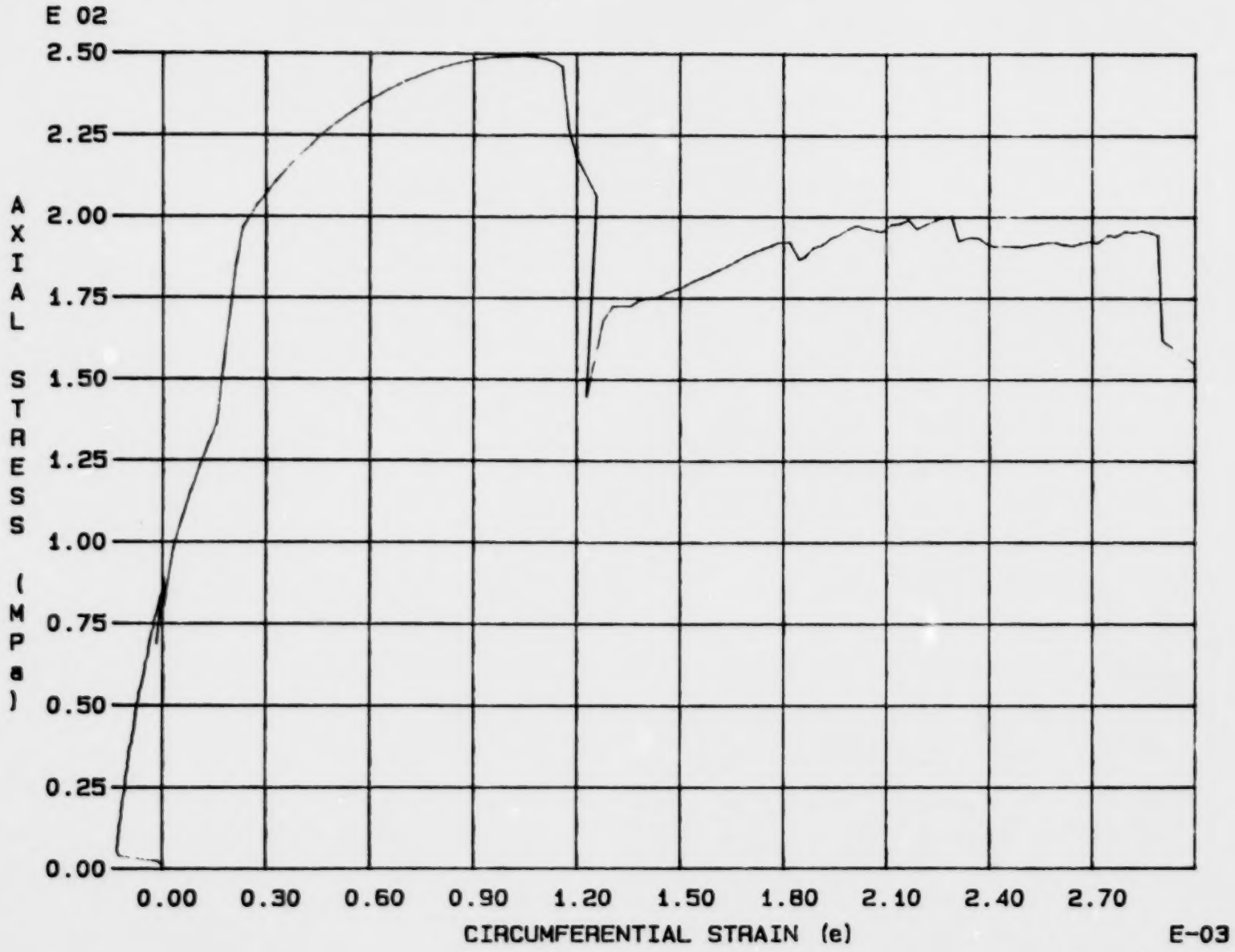


Fig. F-55 E123M

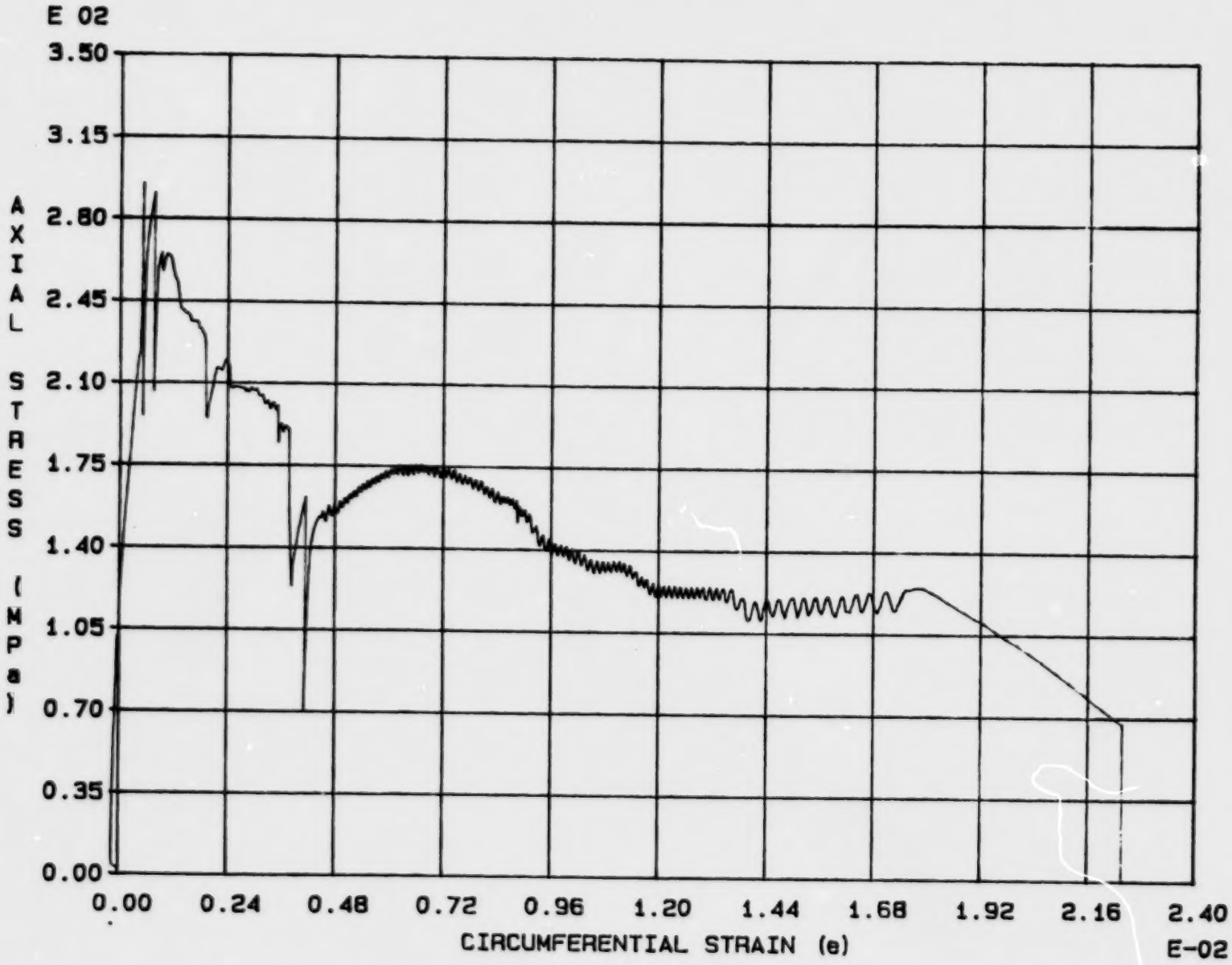


Fig. F-56 E124M

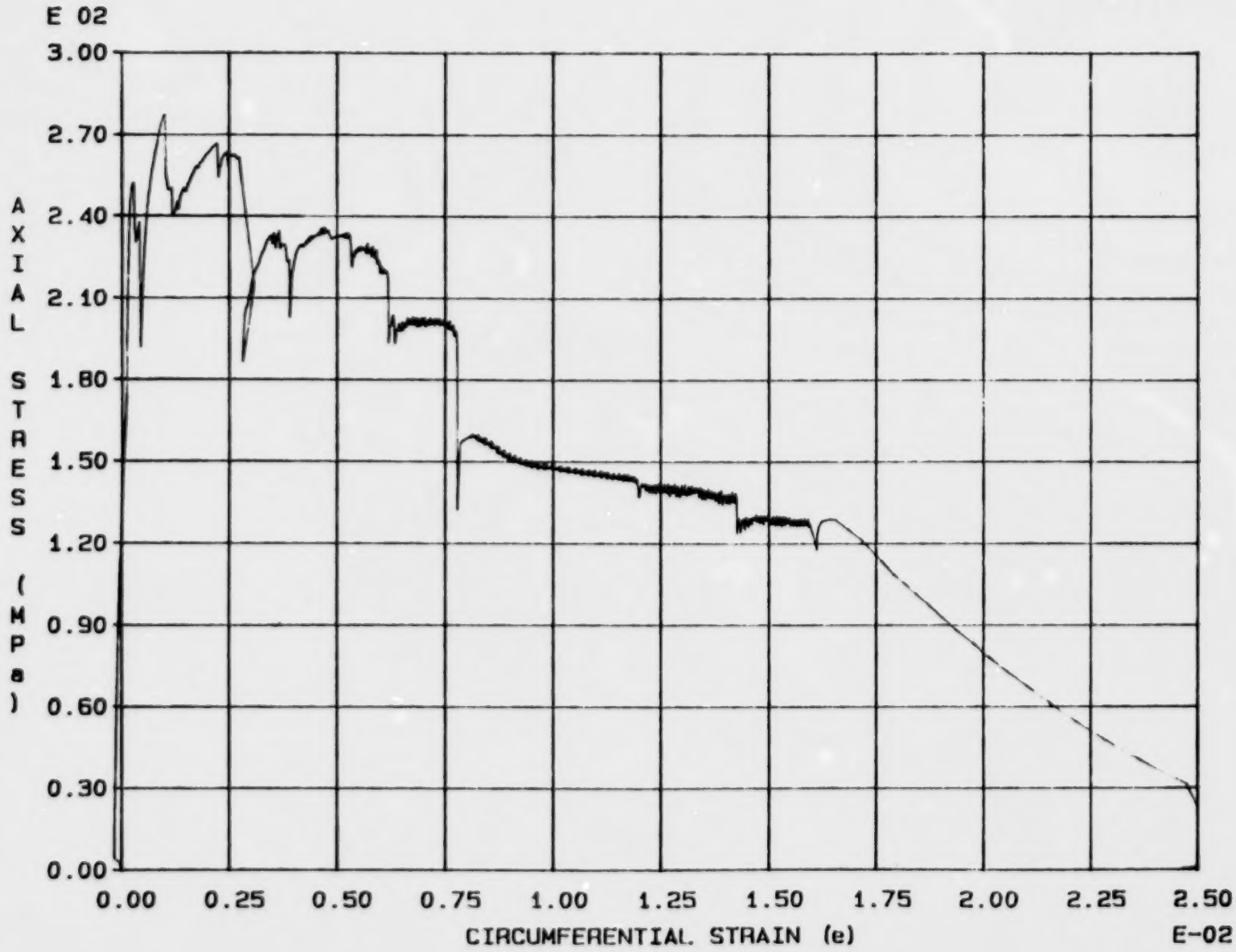


Fig. F-57 E125M

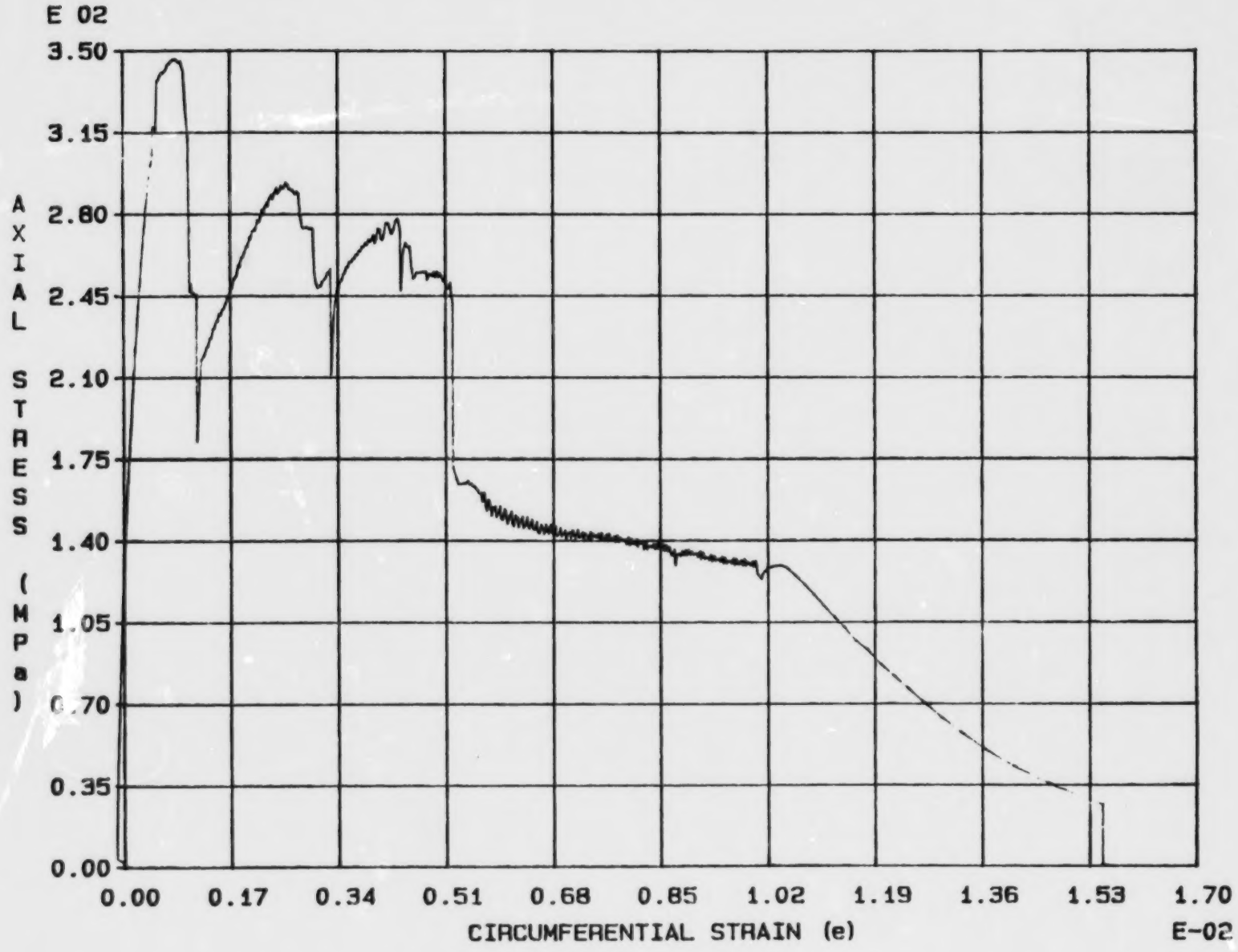


Fig. F-58 E126M

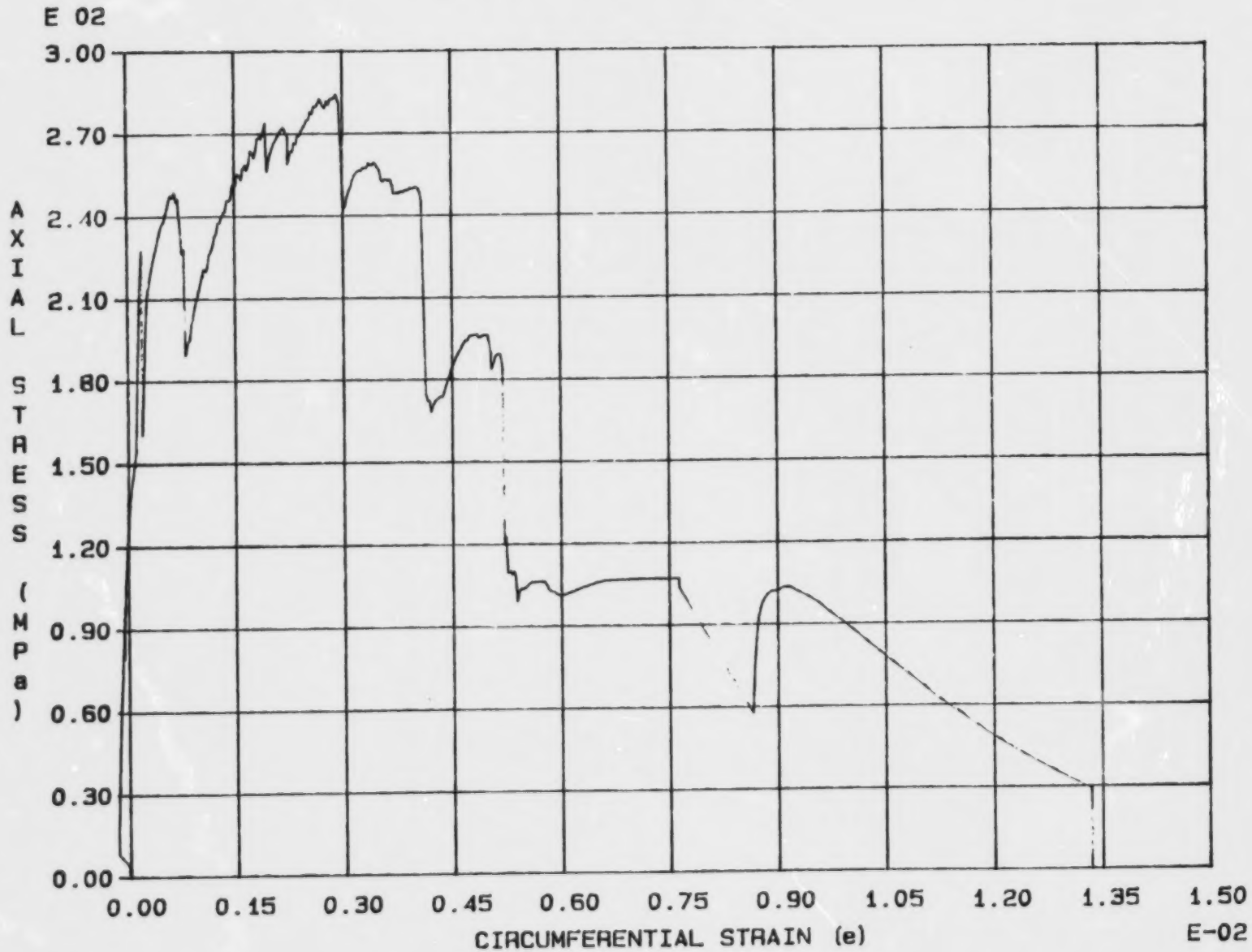


Fig. F-59 E127M

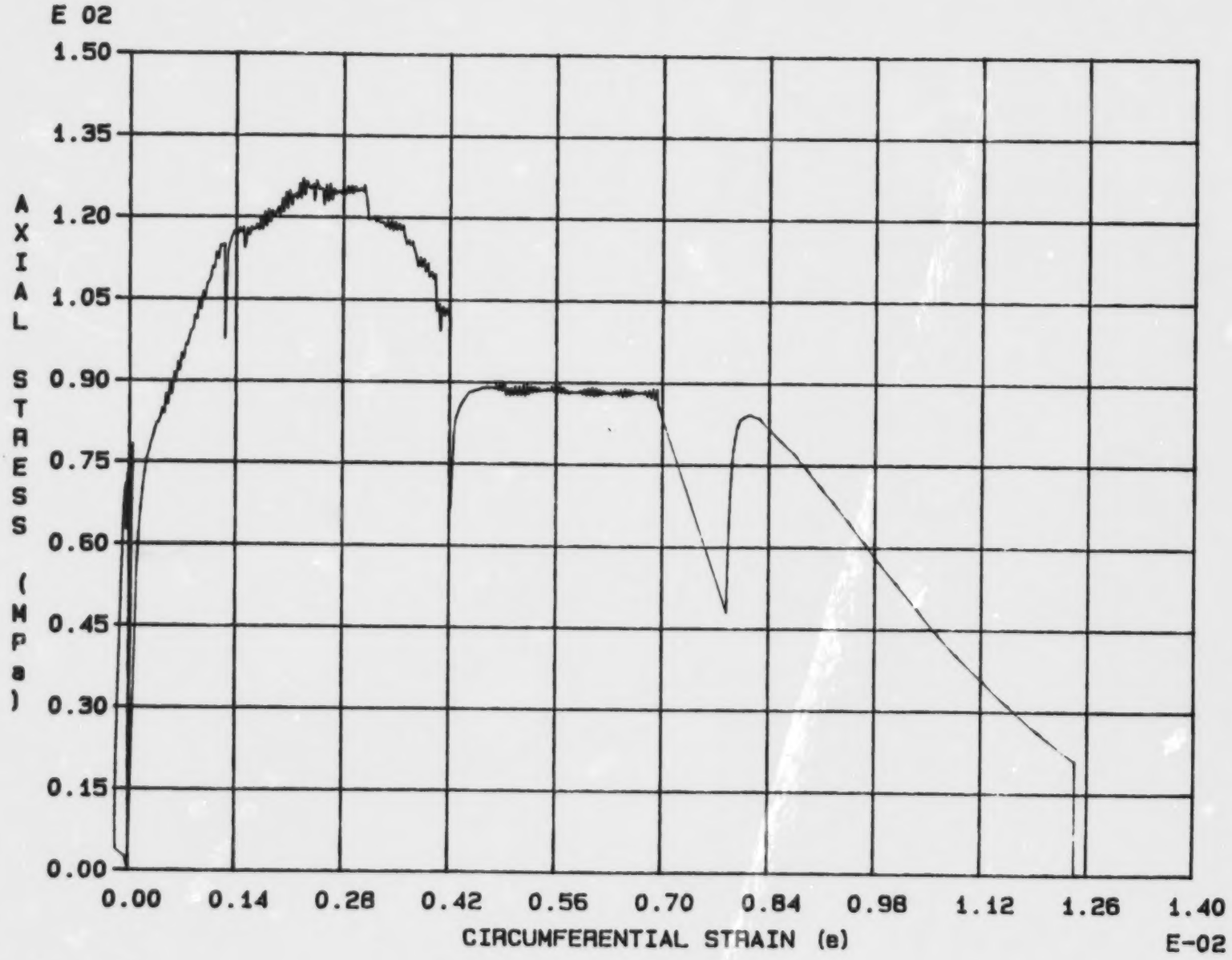


Fig. F-60 E128M

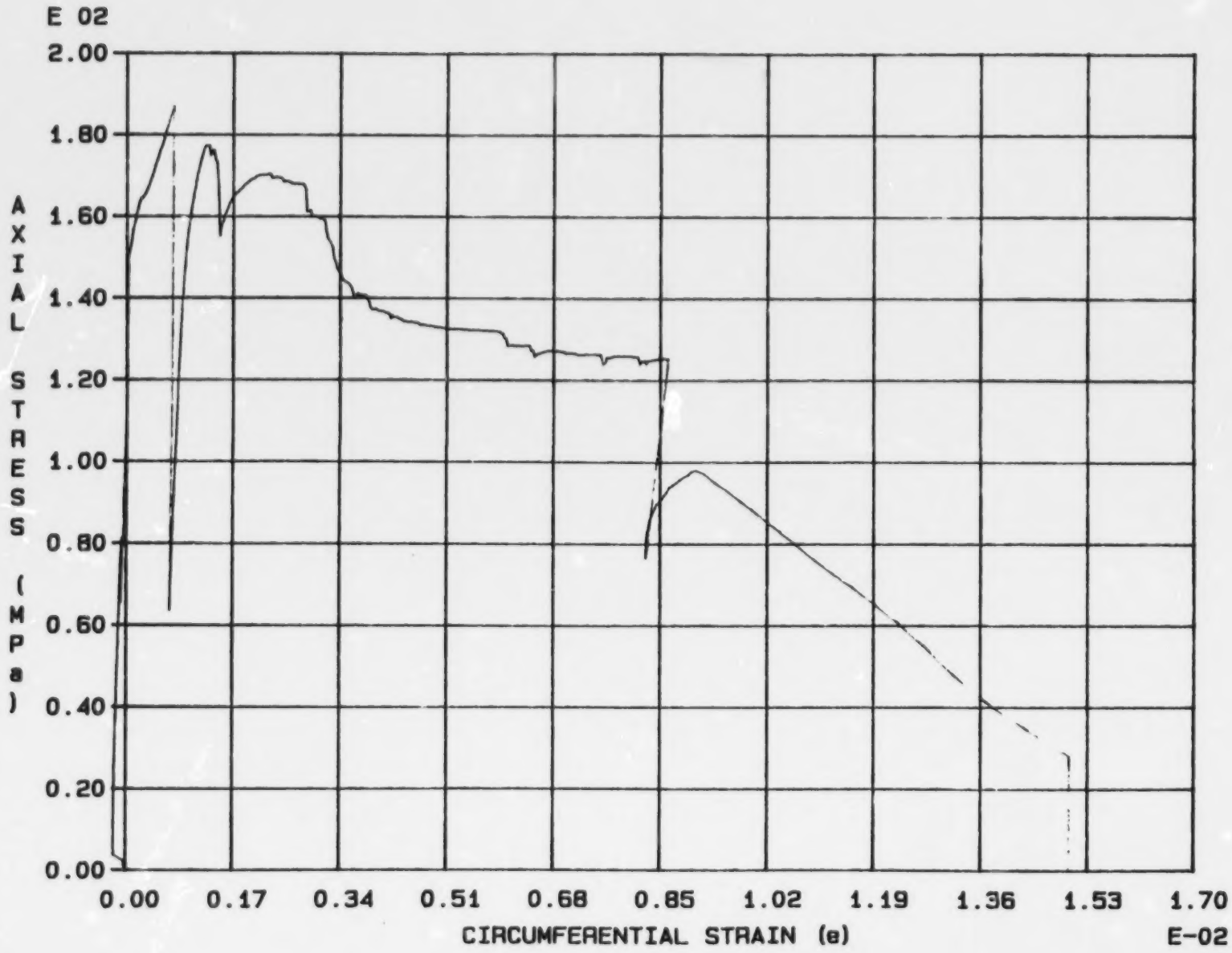


Fig. F-61 E129M

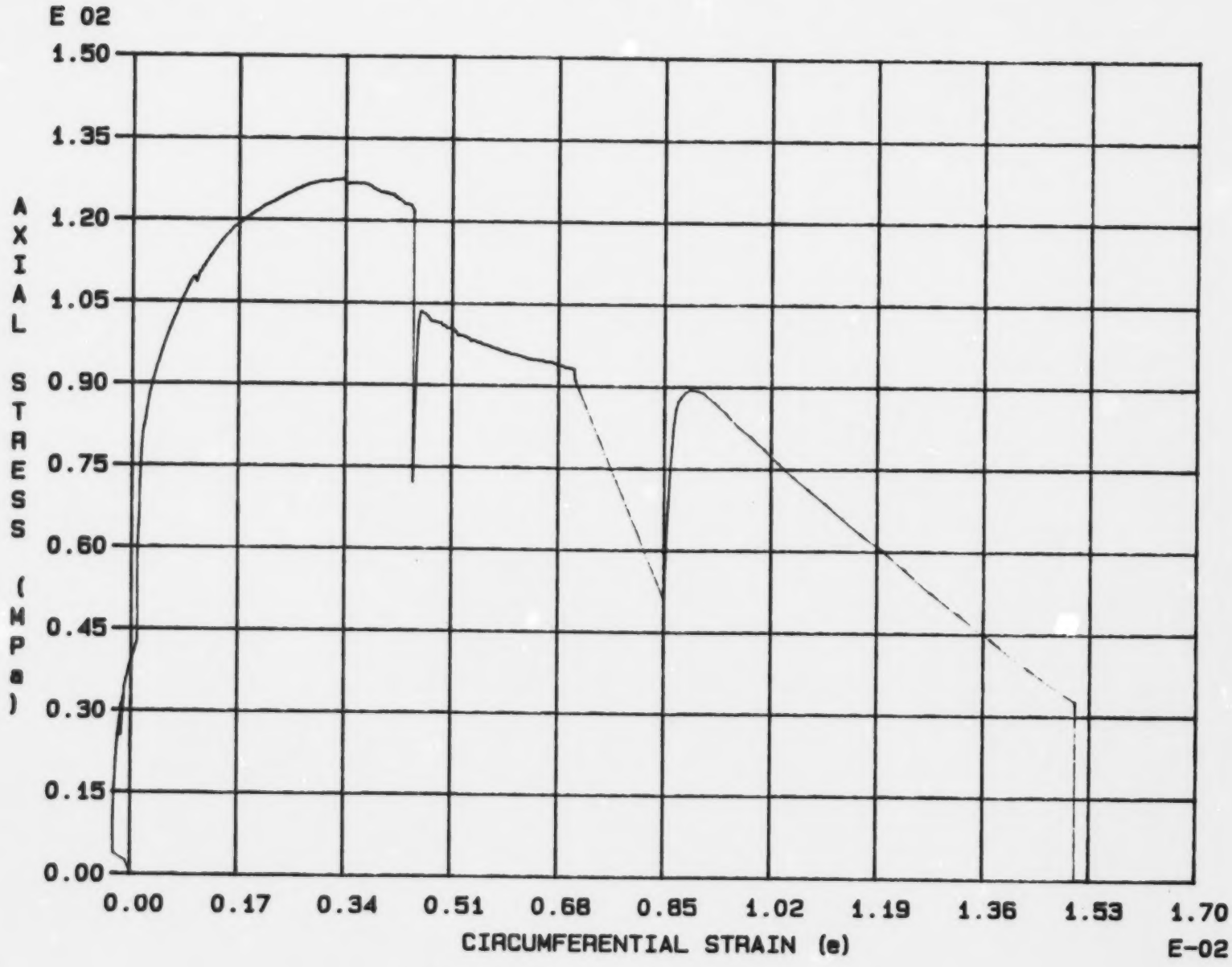


Fig. F-62 E130M

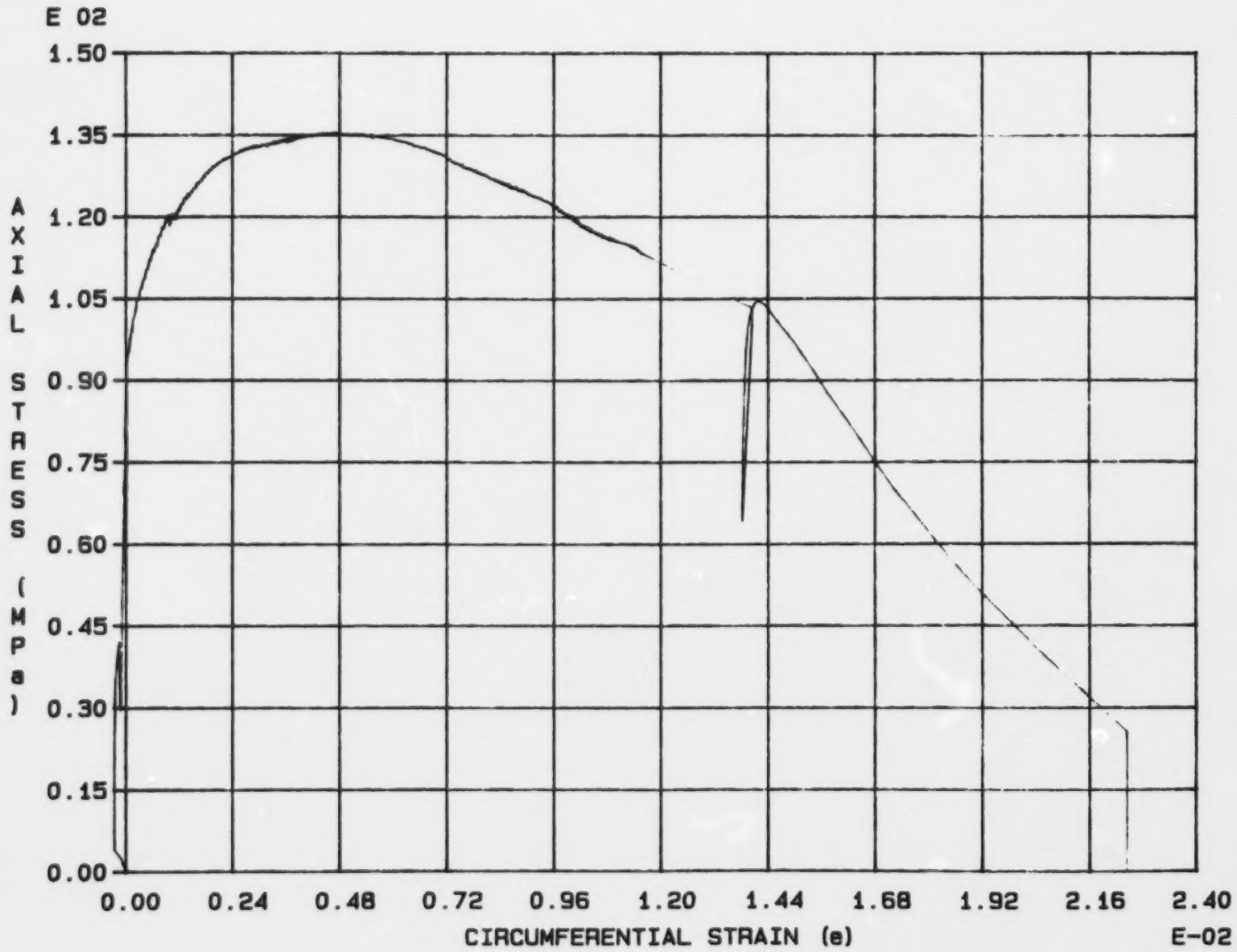


Fig. F-63 E131M

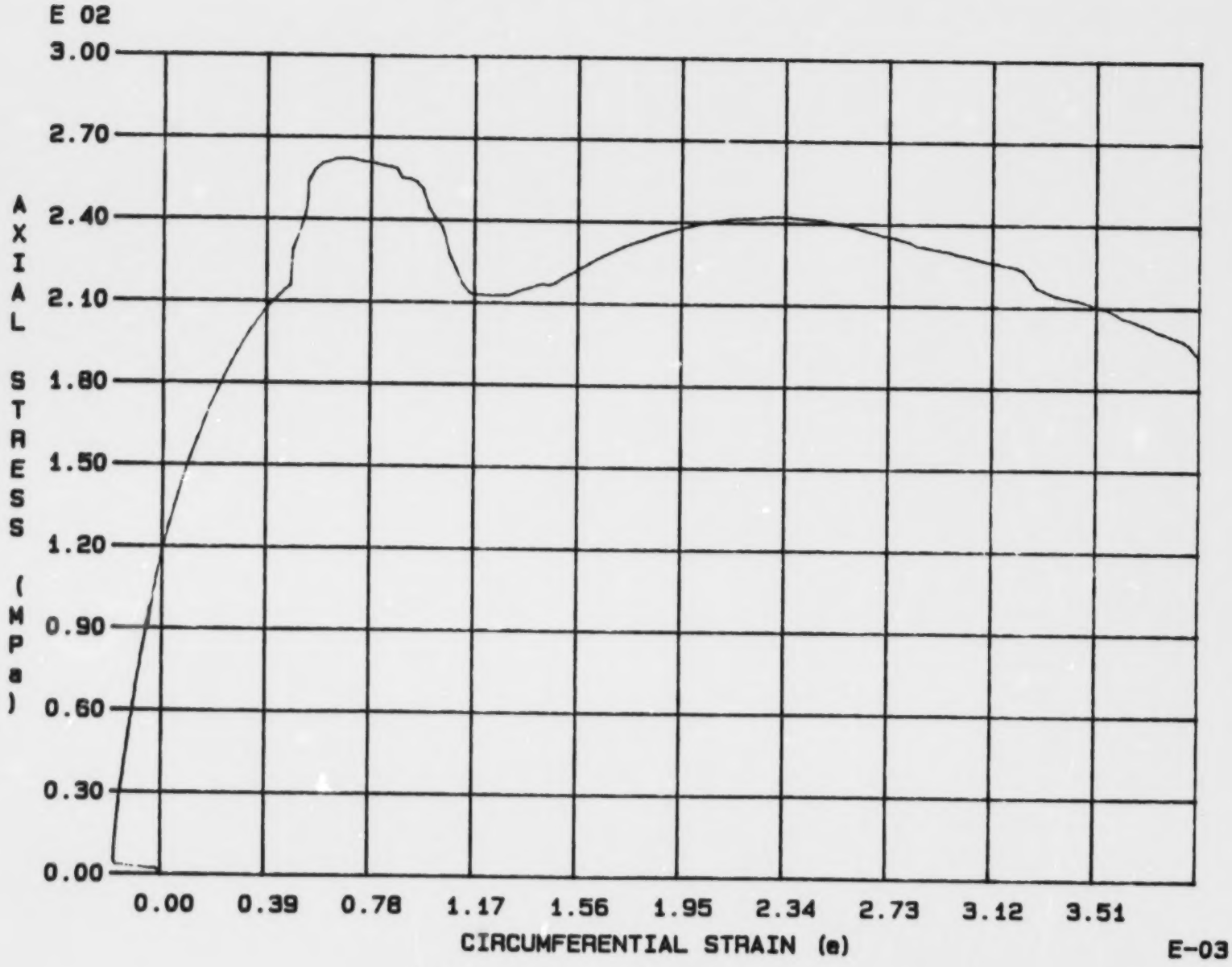


Fig. F-64 F132M

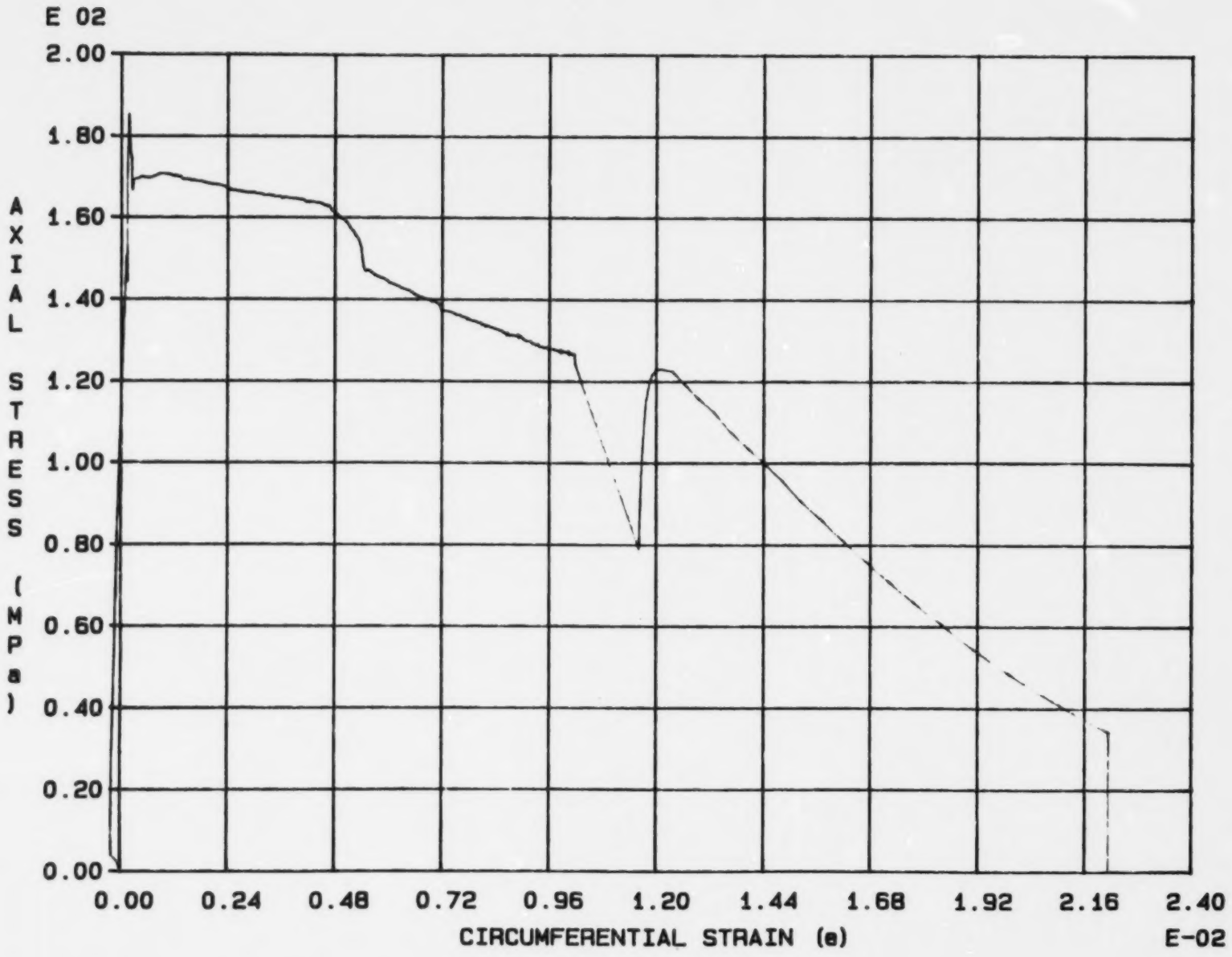


Fig. F-65 E133M

APPENDIX G

POST-FAILURE STRENGTH-CONFINING PRESSURE CURVES

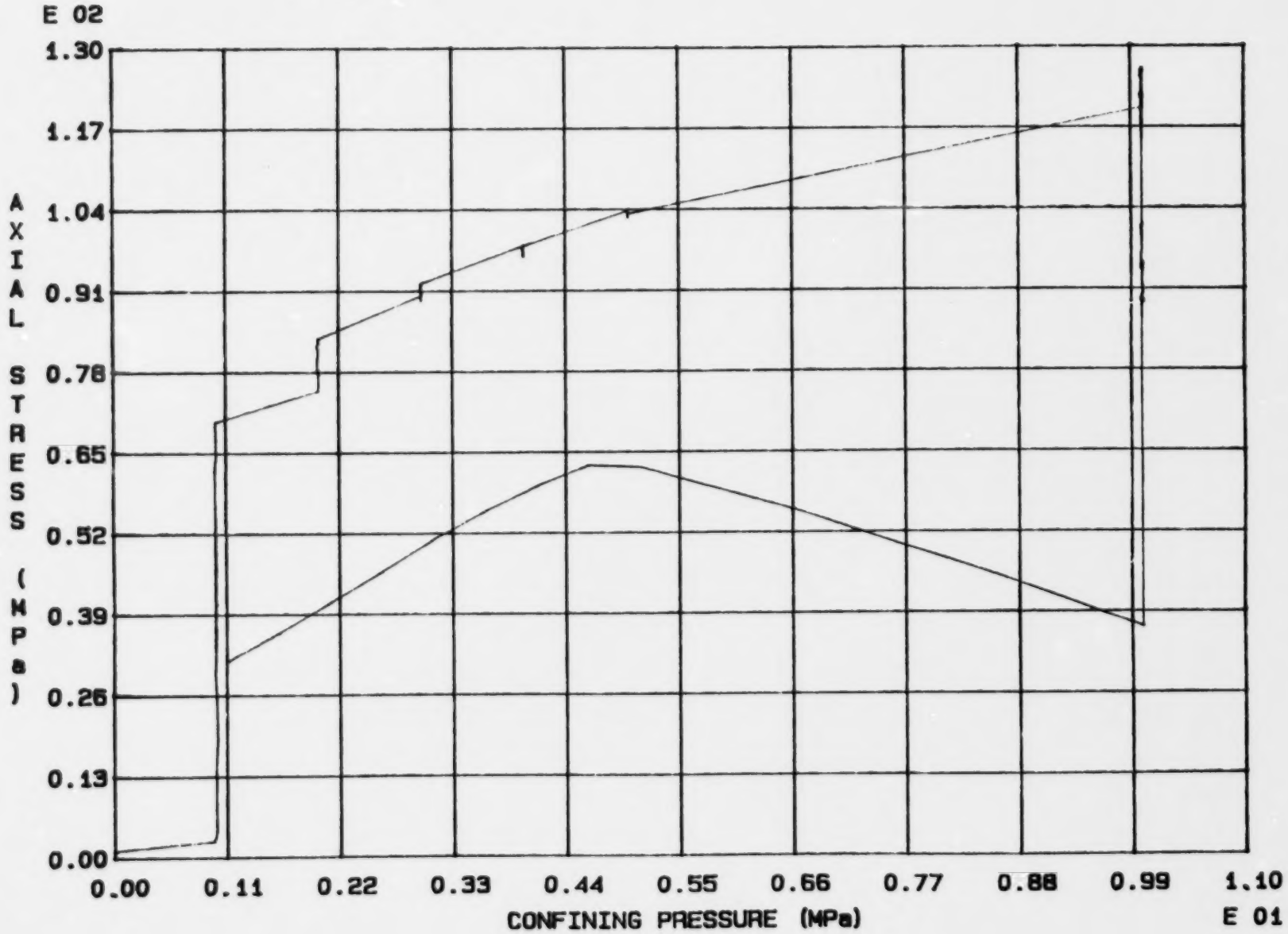

E 02
1.30
1.17
1.04
0.91
0.78
0.65
0.52
0.39
0.26
0.13
0.00
AXIAL STRESS (MPa)
0.00
0.11
0.22
0.33
0.44
0.55
0.66
0.77
0.88
0.99
1.10
CONFINING PRESSURE (MPa)
E 01

Fig. 6-1 E2T

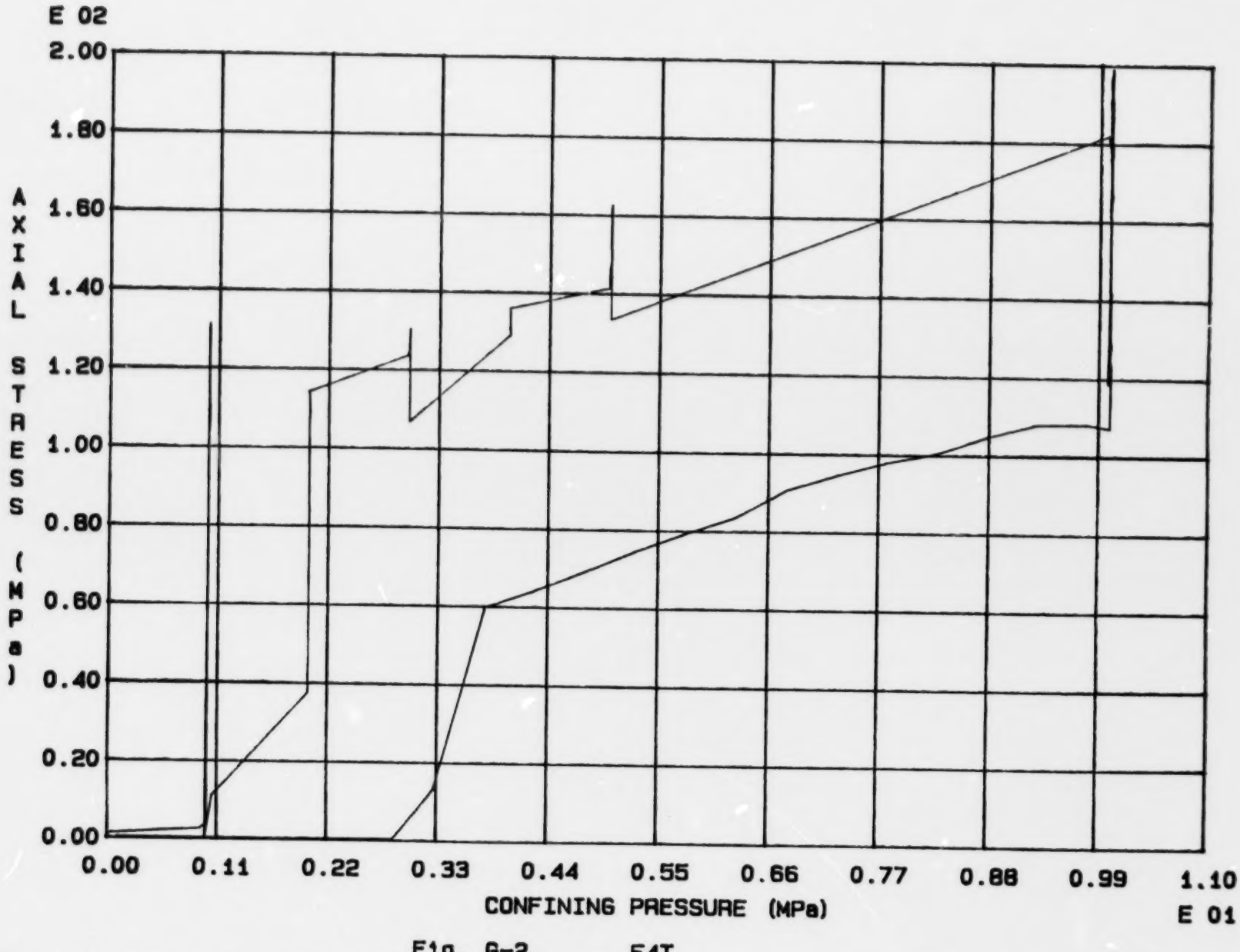

E 02
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
AXIAL STRESS (MPa)
0.00
0.11
0.22
0.33
0.44
0.55
0.66
0.77
0.88
0.99
1.10
CONFINING PRESSURE (MPa)
E 01

Fig. 6-2 E4T

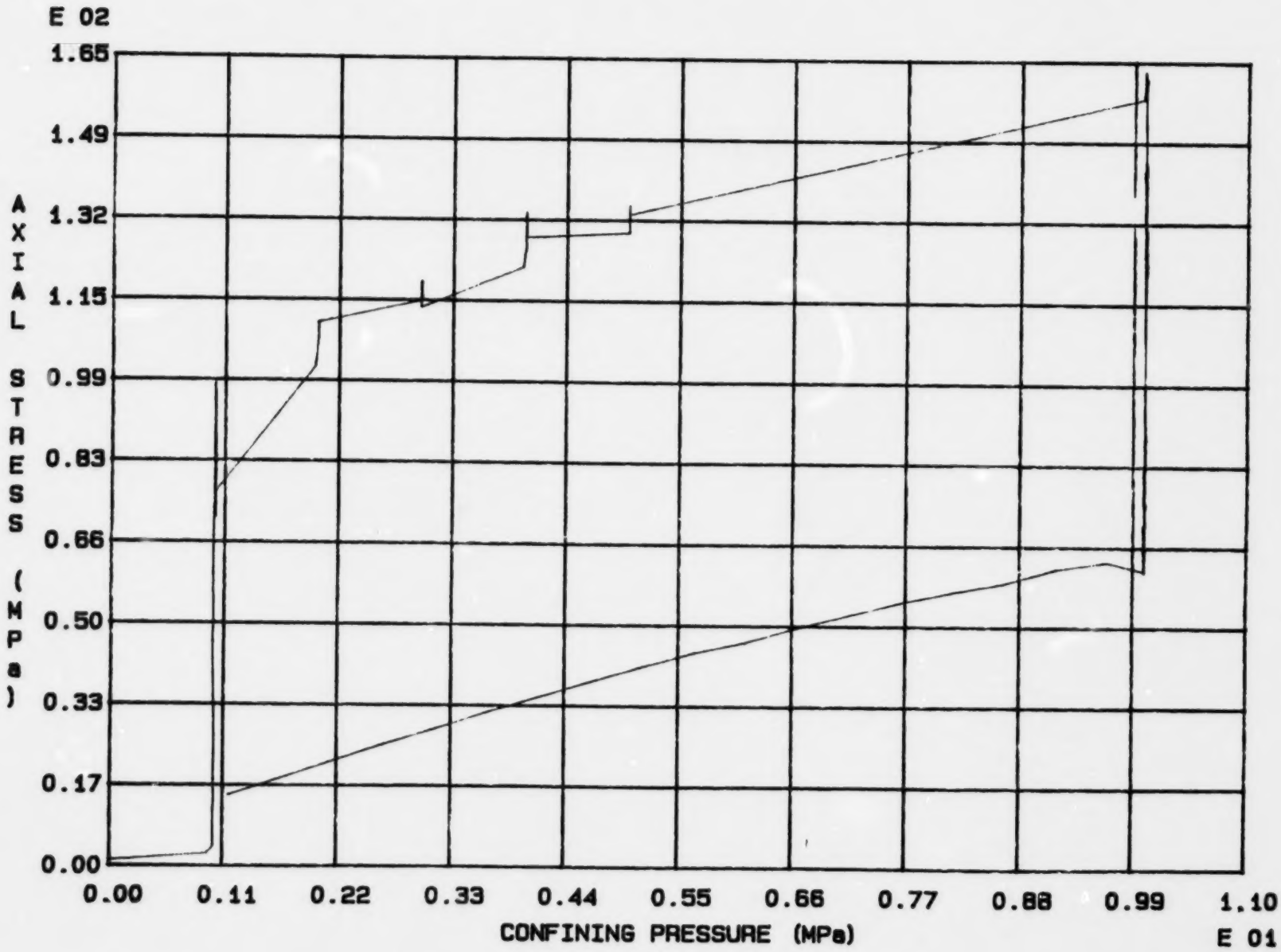

E 02
1.65
1.49
1.32
1.15
0.99
0.83
0.66
0.50
0.33
0.17
0.00
AXIAL STRESS (MPa)
0.00
0.11
0.22
0.33
0.44
0.55
0.66
0.77
0.88
0.99
1.10
CONFINING PRESSURE (MPa)
E 01

Fig. 6-3 E6T

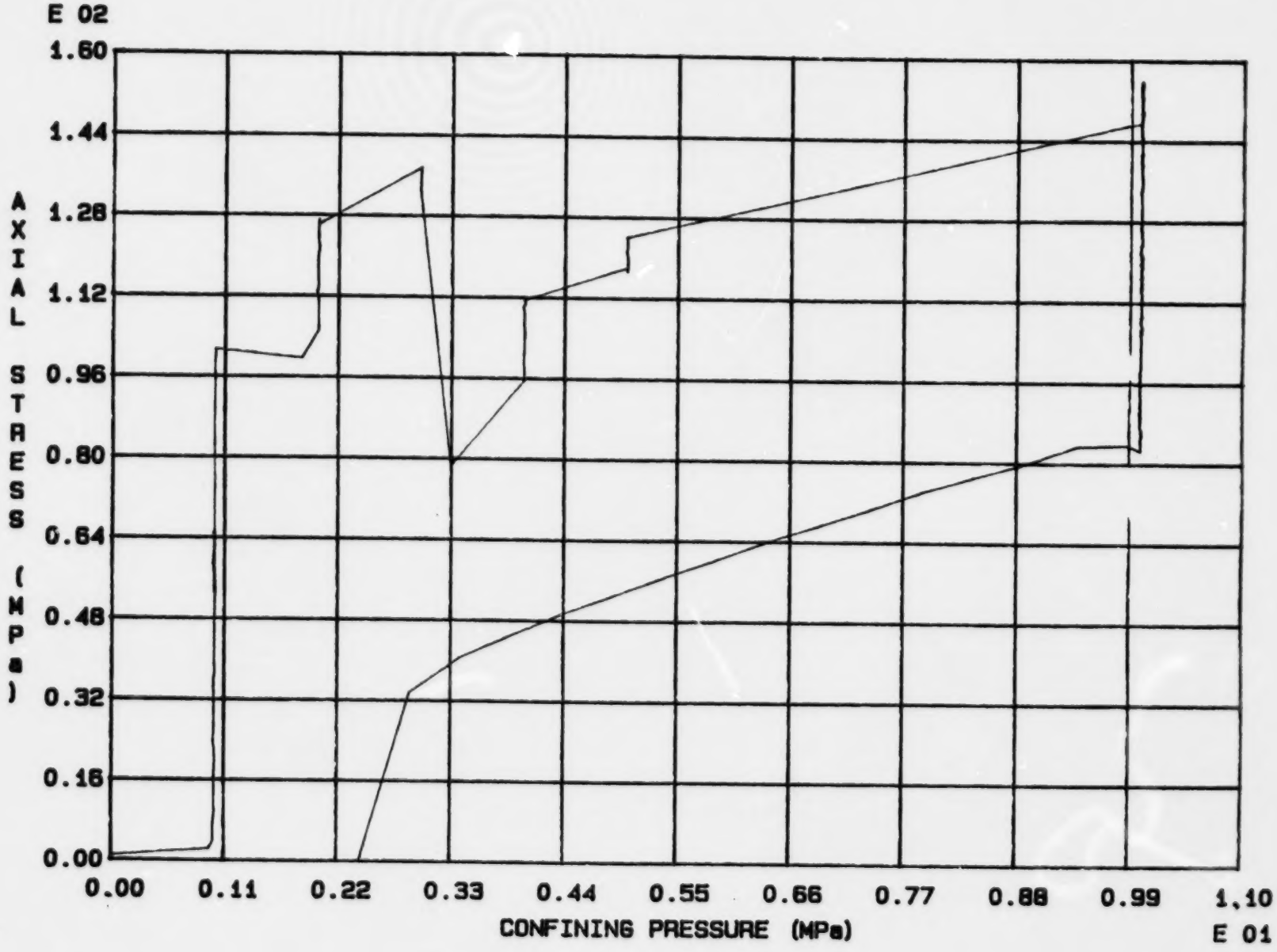

E 02
1.60
1.44
1.28
1.12
0.96
0.80
0.64
0.48
0.32
0.16
0.00
AXIAL STRESS (MPa)
0.00
0.11
0.22
0.33
0.44
0.55
0.66
0.77
0.88
0.99
1.10
E 01
CONFINING PRESSURE (MPa)

Fig. 6-4 E8T

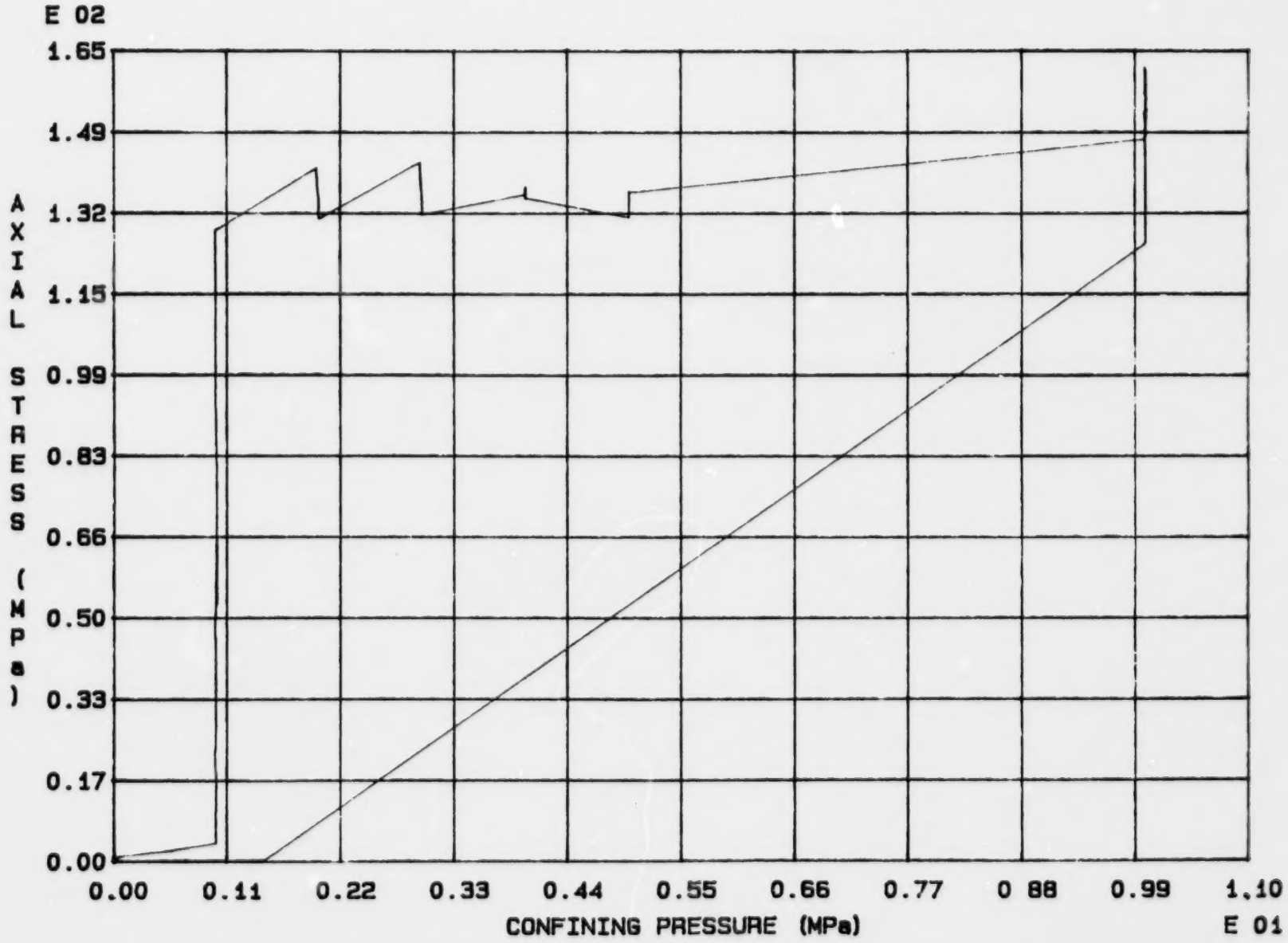

E 02
1.65
1.49
1.32
1.15
0.99
0.83
0.66
0.50
0.33
0.17
0.00
AXIAL STRESS (MPa)
0.00
0.11
0.22
0.33
0.44
0.55
0.66
0.77
0 88
0.99
1.10
CONFINING PRESSURE (MPa)
E 01

Fig. 6-5 E10T

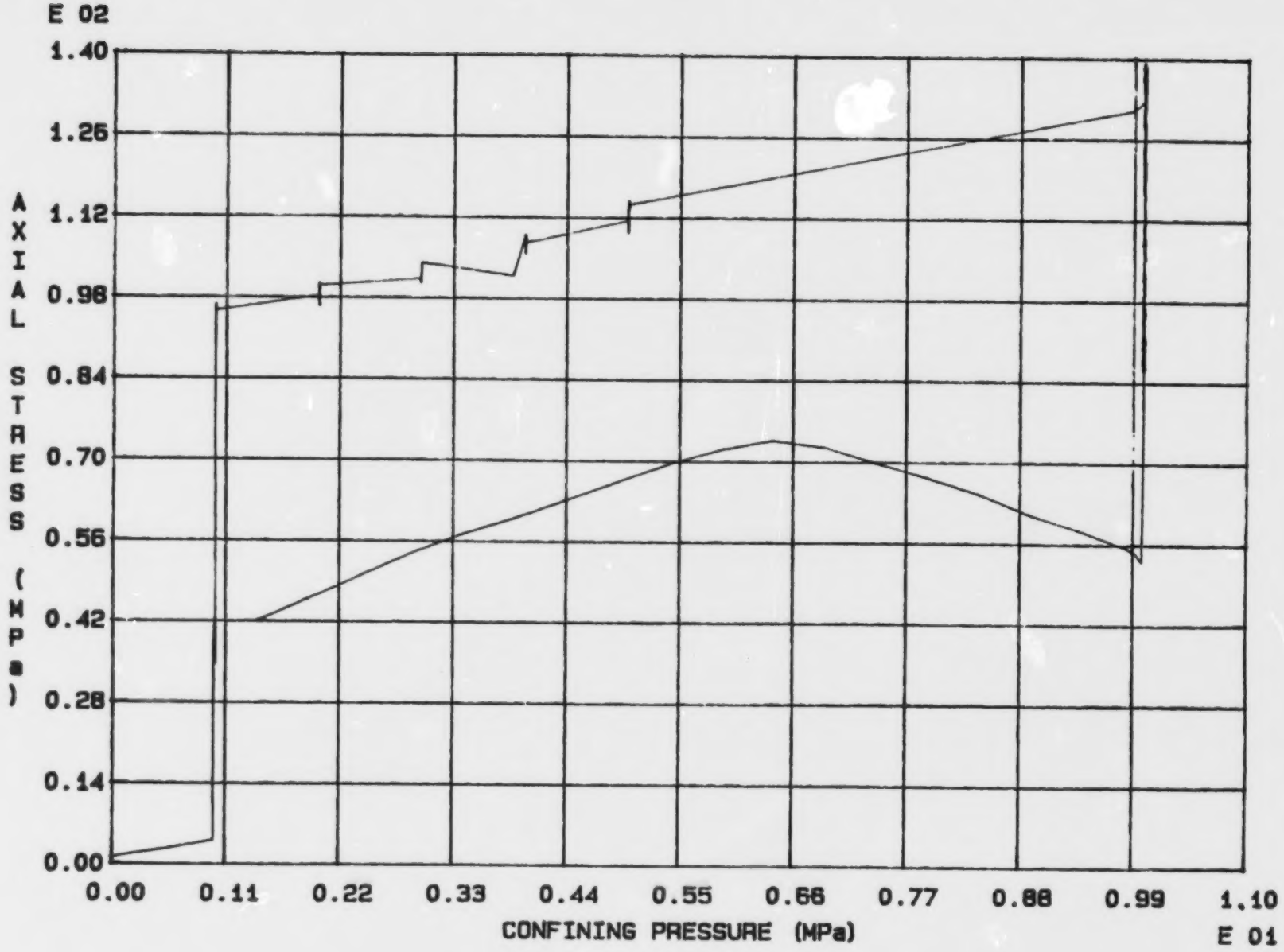

E 02
1.40
1.26
1.12
0.98
0.84
0.70
0.56
0.42
0.28
0.14
0.00
AXIAL STRESS (MPa)
0.00
0.11
0.22
0.33
0.44
0.55
0.66
0.77
0.88
0.99
1.10
CONFINING PRESSURE (MPa)
E 01

Fig. 6-6 E12T

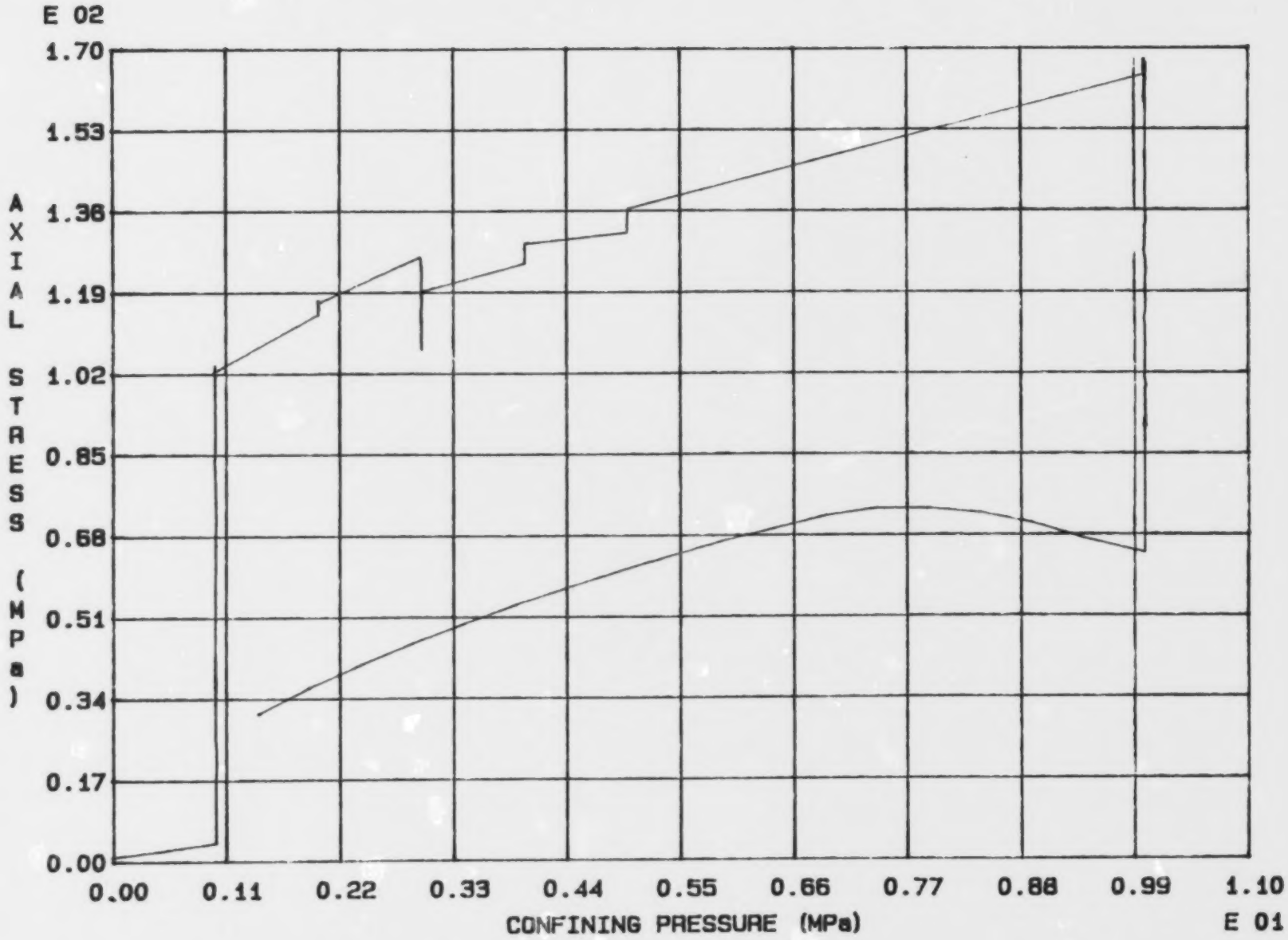

E 02
1.70
1.53
1.36
1.19
1.02
0.85
0.68
0.51
0.34
0.17
0.00
AXIAL STRESS (MPa)
0.00
0.11
0.22
0.33
0.44
0.55
0.66
0.77
0.88
0.99
1.10
CONFINING PRESSURE (MPa)
E 01

Fig. 6-7 E14T

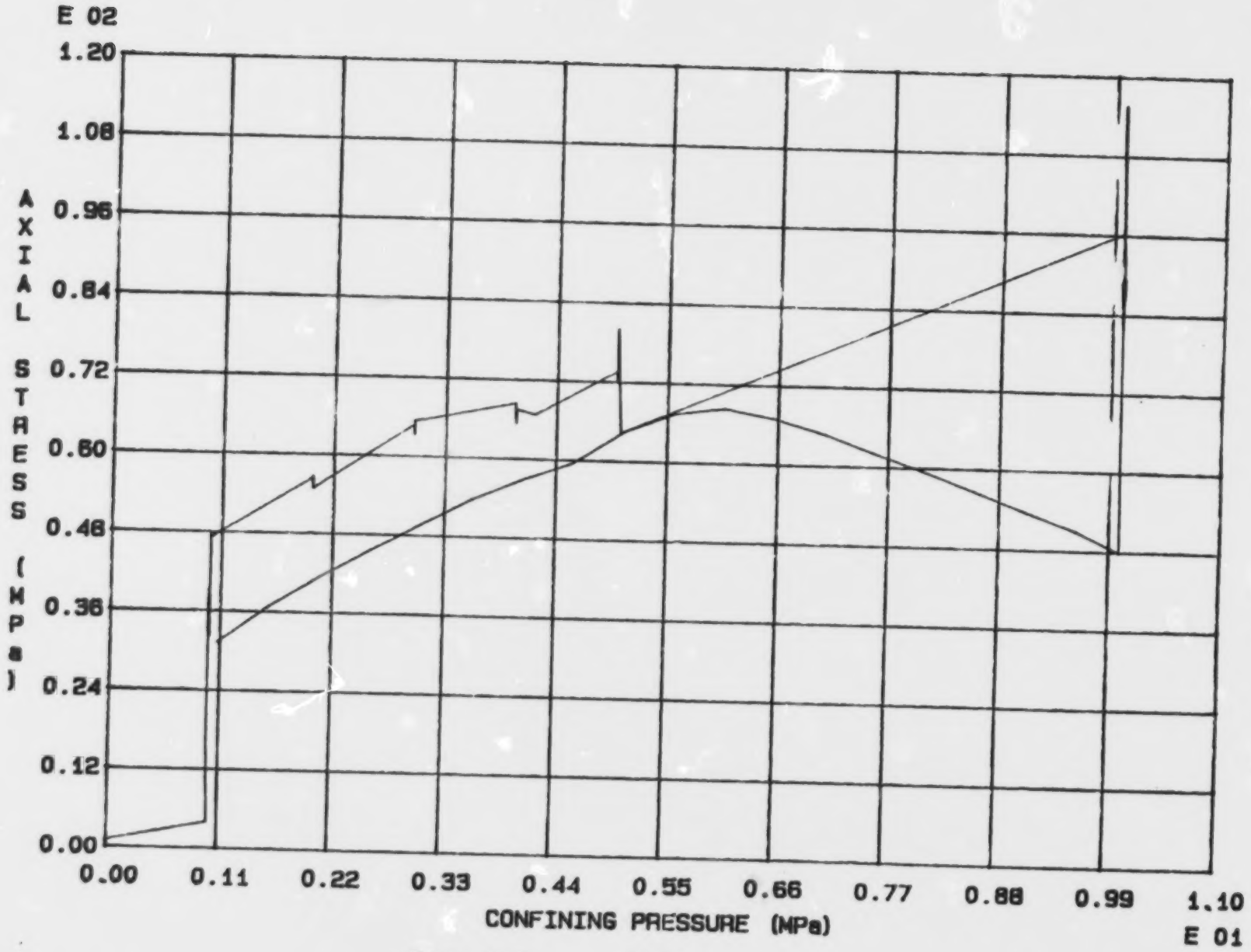

E 02
1.20
1.08
0.96
0.84
0.72
0.60
0.48
0.36
0.24
0.12
0.00
AXIAL STRESS (MPa)
0.00
0.11
0.22
0.33
0.44
0.55
0.66
0.77
0.88
0.99
1.10
E 01
CONFINING PRESSURE (MPa)

Fig. 6-8 E16T

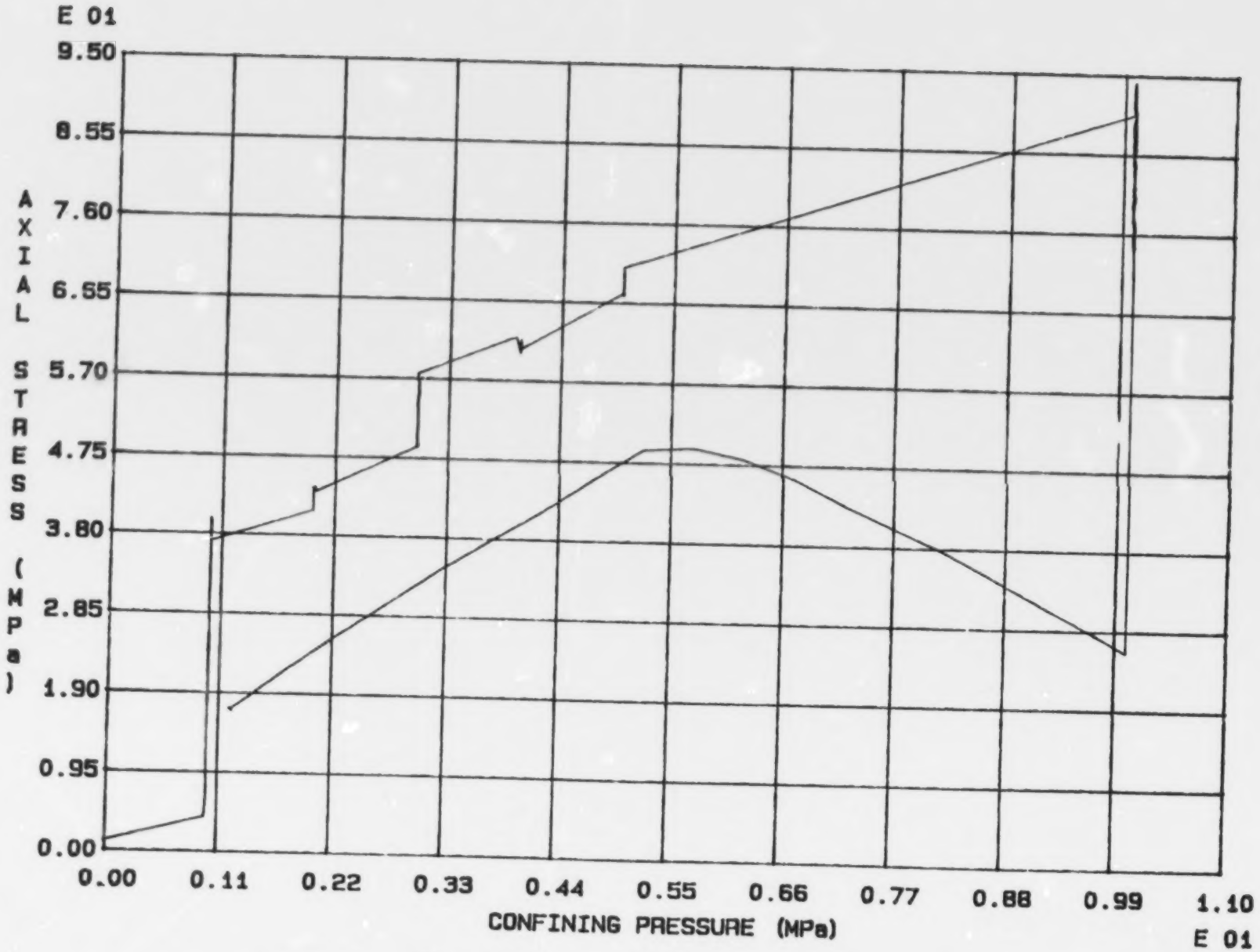

E 01
9.50
8.55
7.60
6.65
5.70
4.75
3.80
2.85
1.90
0.95
0.00
AXIAL STRESS (MPa)
0.00
0.11
0.22
0.33
0.44
0.55
0.66
0.77
0.88
0.99
1.10
CONFINING PRESSURE (MPa)
E 01

Fig. 6-9 E18T

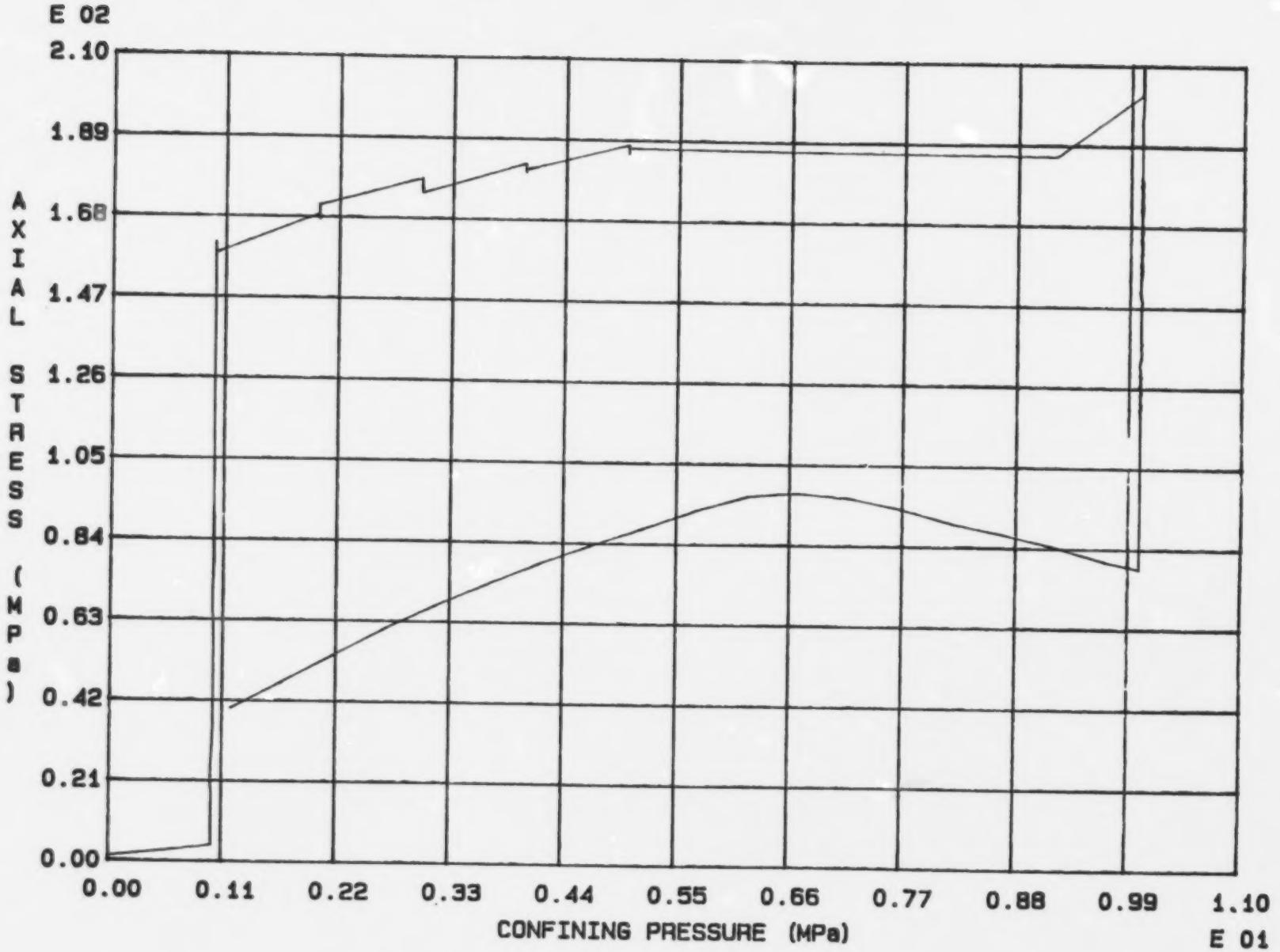

E 02
2.10
1.89
1.68
1.47
1.26
1.05
0.84
0.63
0.42
0.21
0.00
AXIAL STRESS (MPa)
0.00
0.11
0.22
0.33
0.44
0.55
0.66
0.77
0.88
0.99
1.10
CONFINING PRESSURE (MPa)
E 01

Fig. G-10 E20T

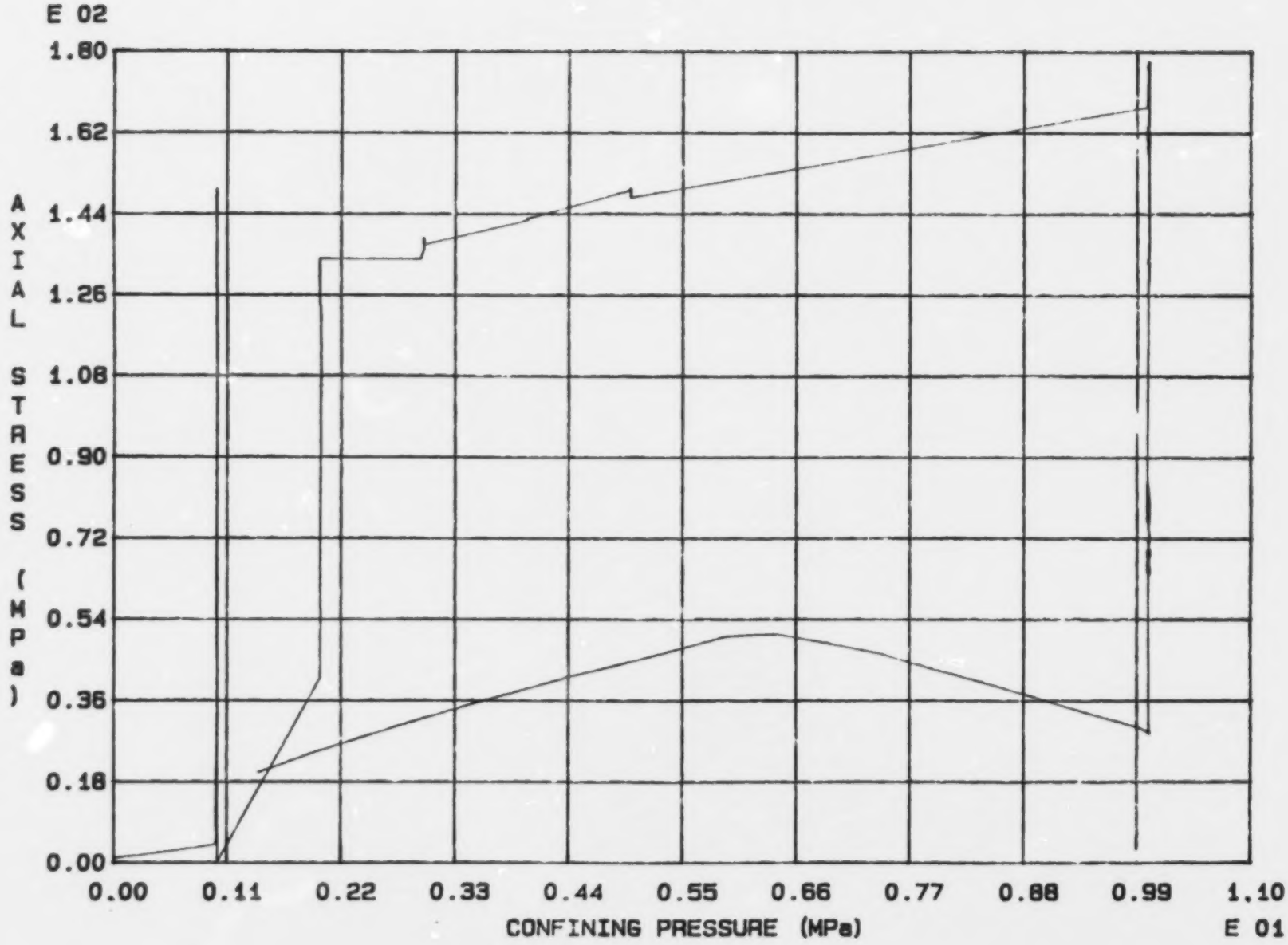

E 02
1.80
1.62
1.44
1.26
1.08
0.90
0.72
0.54
0.36
0.18
0.00
AXIAL STRESS (MPa)
0.00
0.11
0.22
0.33
0.44
0.55
0.66
0.77
0.88
0.99
1.10
CONFINING PRESSURE (MPa)
E 01

Fig. 6-11 E22T

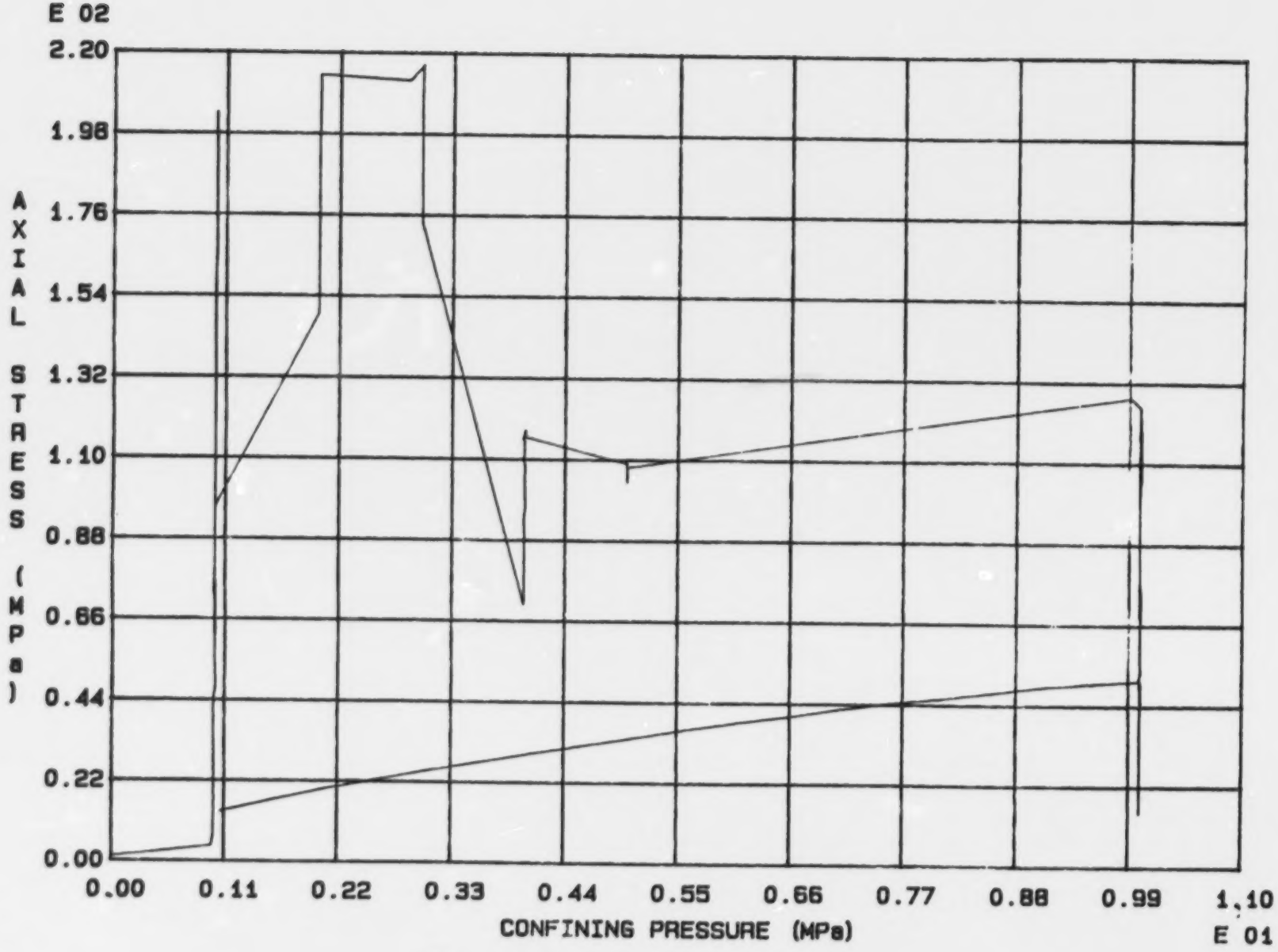

E 02
2.20
1.98
1.76
1.54
1.32
1.10
0.88
0.66
0.44
0.22
0.00
AXIAL STRESS (MPa)
0.00
0.11
0.22
0.33
0.44
0.55
0.66
0.77
0.88
0.99
1.10
E 01
CONFINING PRESSURE (MPa)

Fig. 6-12 E24T

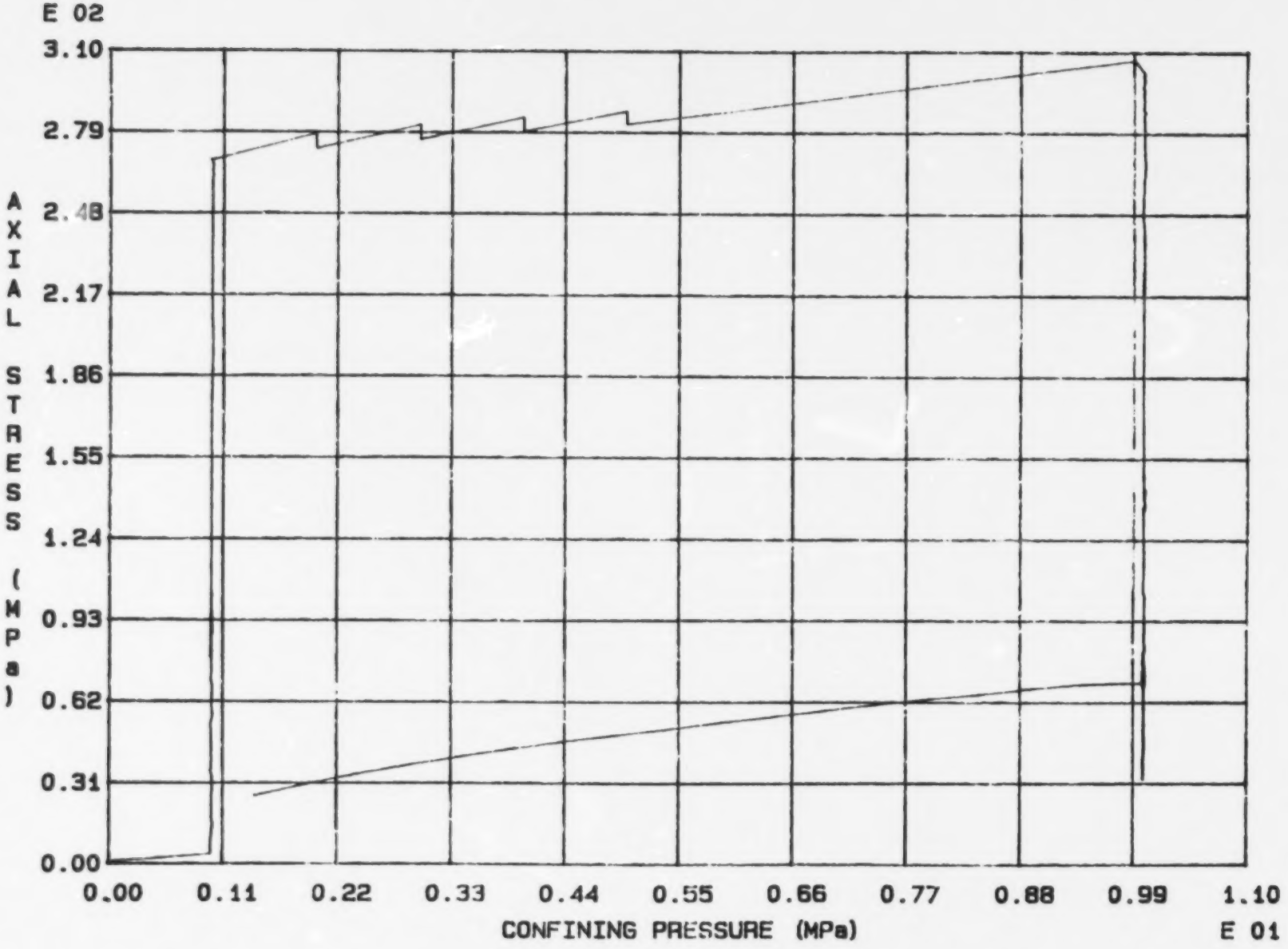

E 02
3.10
2.79
2.48
2.17
1.86
1.55
1.24
0.93
0.62
0.31
0.00
AXIAL STRESS (MPa)
0.00
0.11
0.22
0.33
0.44
0.55
0.66
0.77
0.88
0.99
1.10
CONFINING PRESSURE (MPa)
E 01

Fig. G-13 E26T

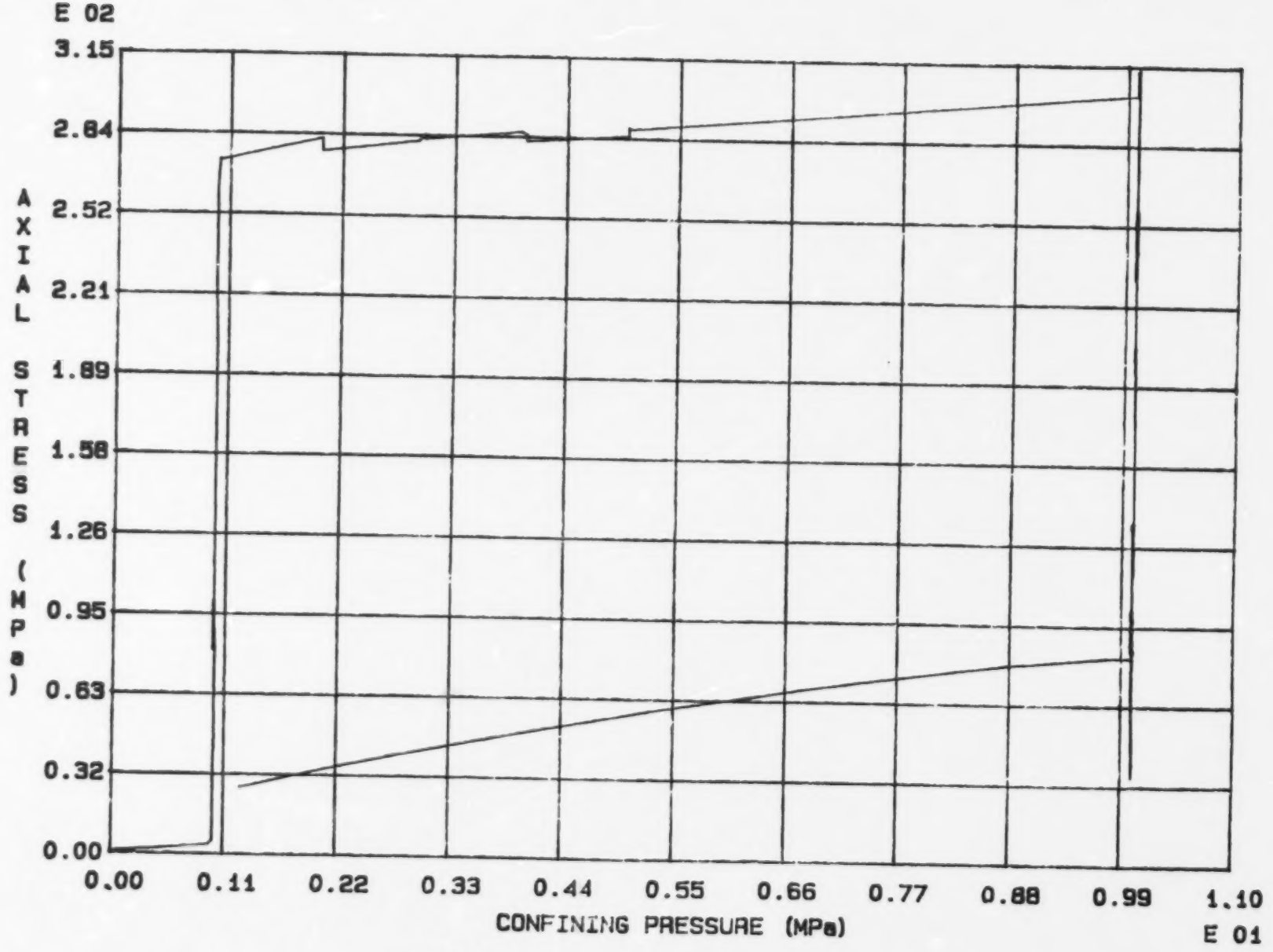

E 02
3.15
2.84
2.52
2.21
1.89
1.58
1.26
0.95
0.63
0.32
0.00
AXIAL STRESS (MPa)
0.00
0.11
0.22
0.33
0.44
0.55
0.66
0.77
0.88
0.99
1.10
E 01
CONFINING PRESSURE (MPa)

Fig. 6-14 E28T

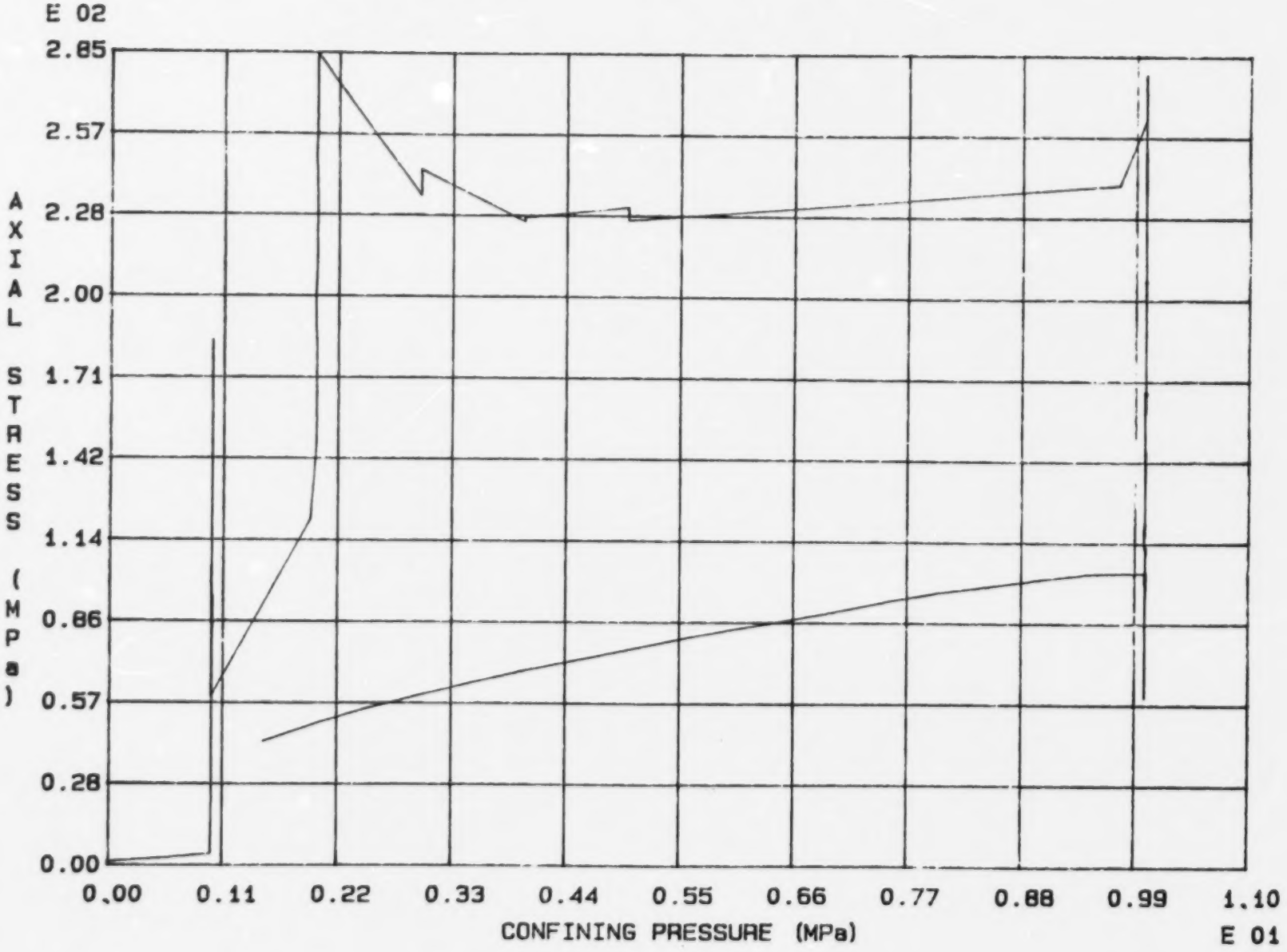

E 02
2.85
2.57
2.28
2.00
1.71
1.42
1.14
0.86
0.57
0.28
0.00
AXIAL STRESS (MPa)
0.00
0.11
0.22
0.33
0.44
0.55
0.66
0.77
0.88
0.99
1.10
CONFINING PRESSURE (MPa)
E 01

Fig. G-15 E30T

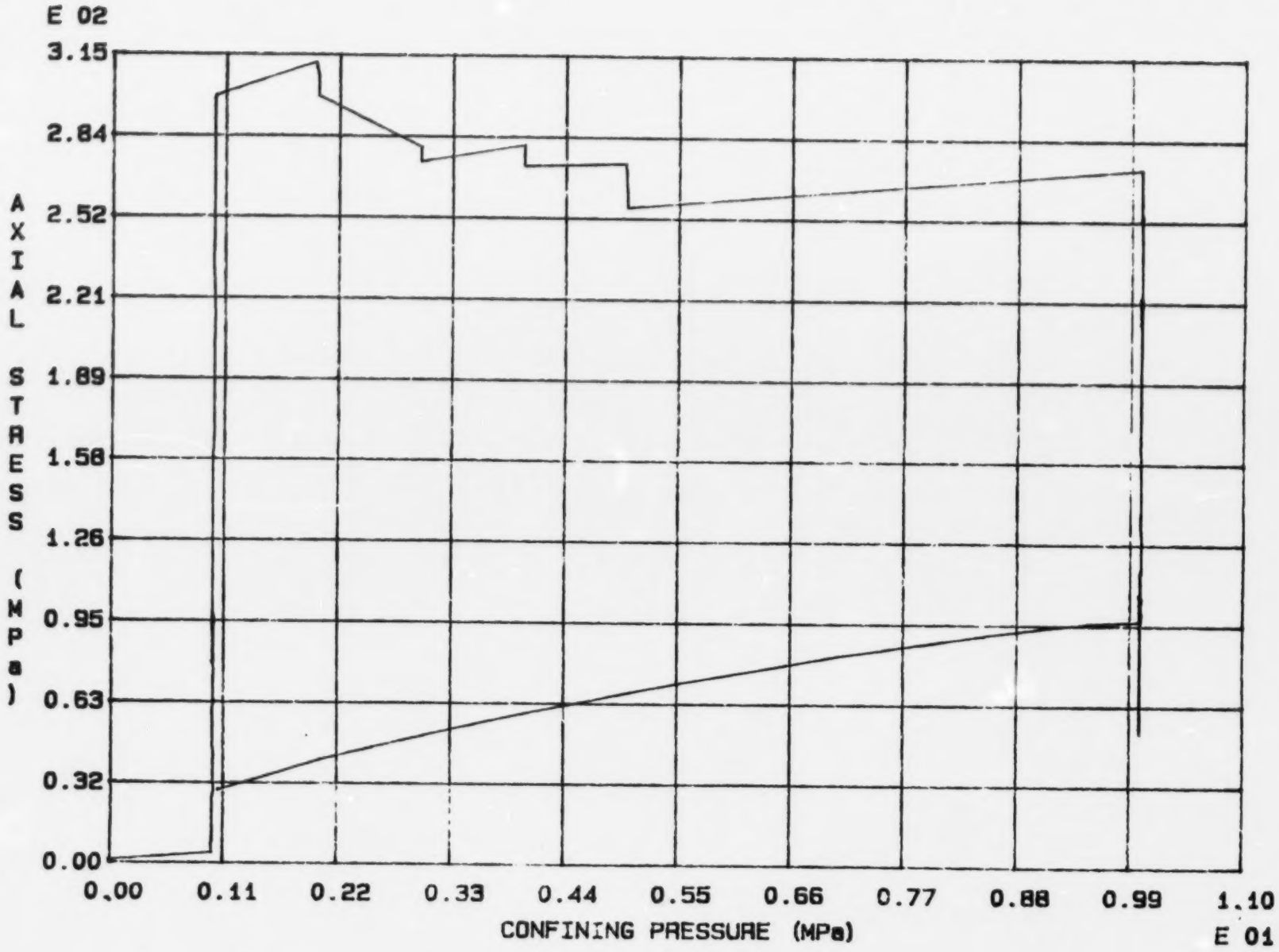

E 02
3.15
2.84
2.52
2.21
1.89
1.58
1.26
0.95
0.63
0.32
0.00
AXIAL STRESS (MPa)
0.00
0.11
0.22
0.33
0.44
0.55
0.66
0.77
0.88
0.99
1.10
CONFINING PRESSURE (MPa)
E 01

Fig. 6-16 E32T

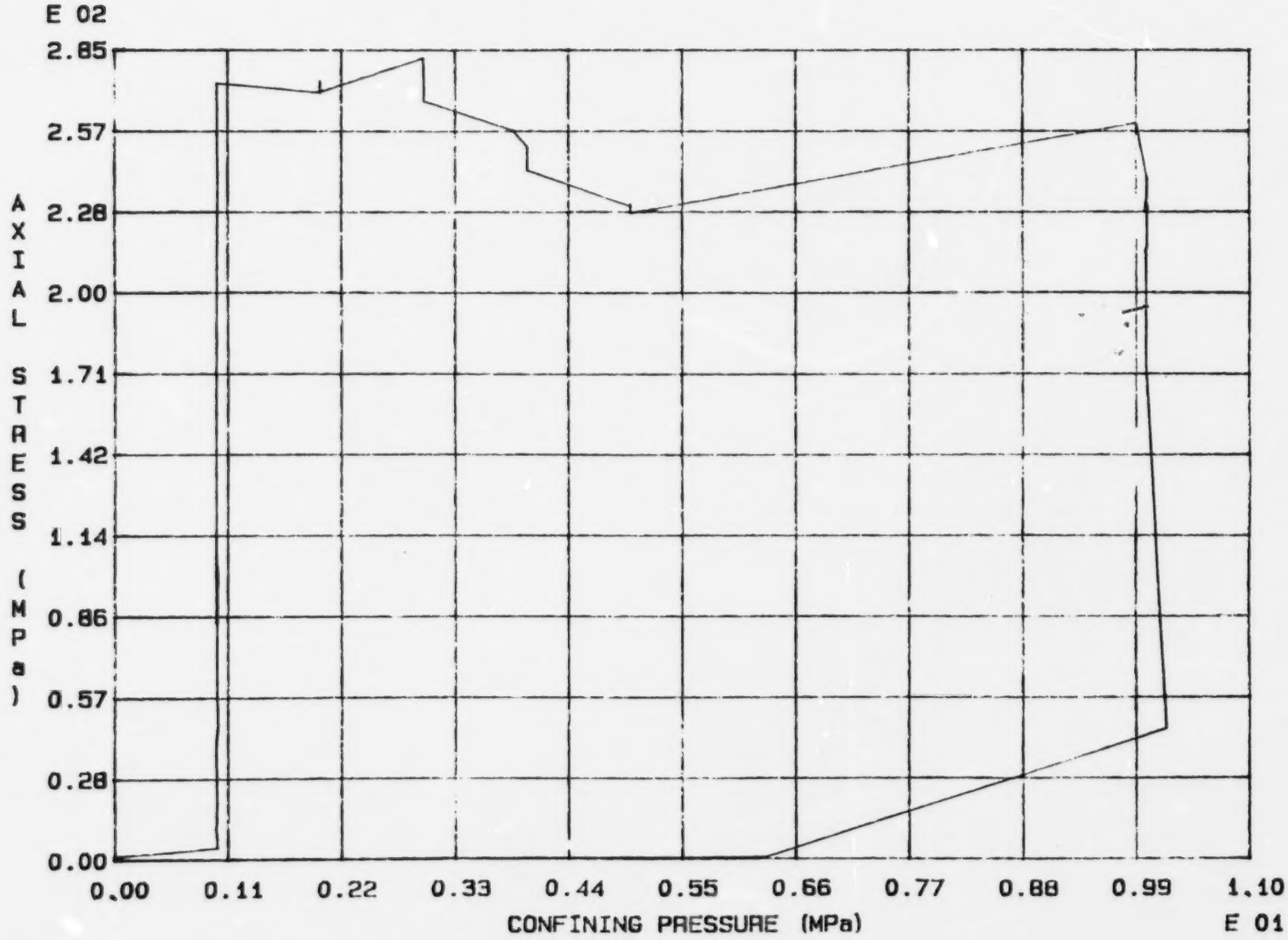

E 02
2.85
2.57
2.28
2.00
1.71
1.42
1.14
0.86
0.57
0.28
0.00
AXIAL STRESS (MPa)
0.00
0.11
0.22
0.33
0.44
0.55
0.66
0.77
0.88
0.99
1.10
E 01
CONFINING PRESSURE (MPa)

Fig. G-17 E34T

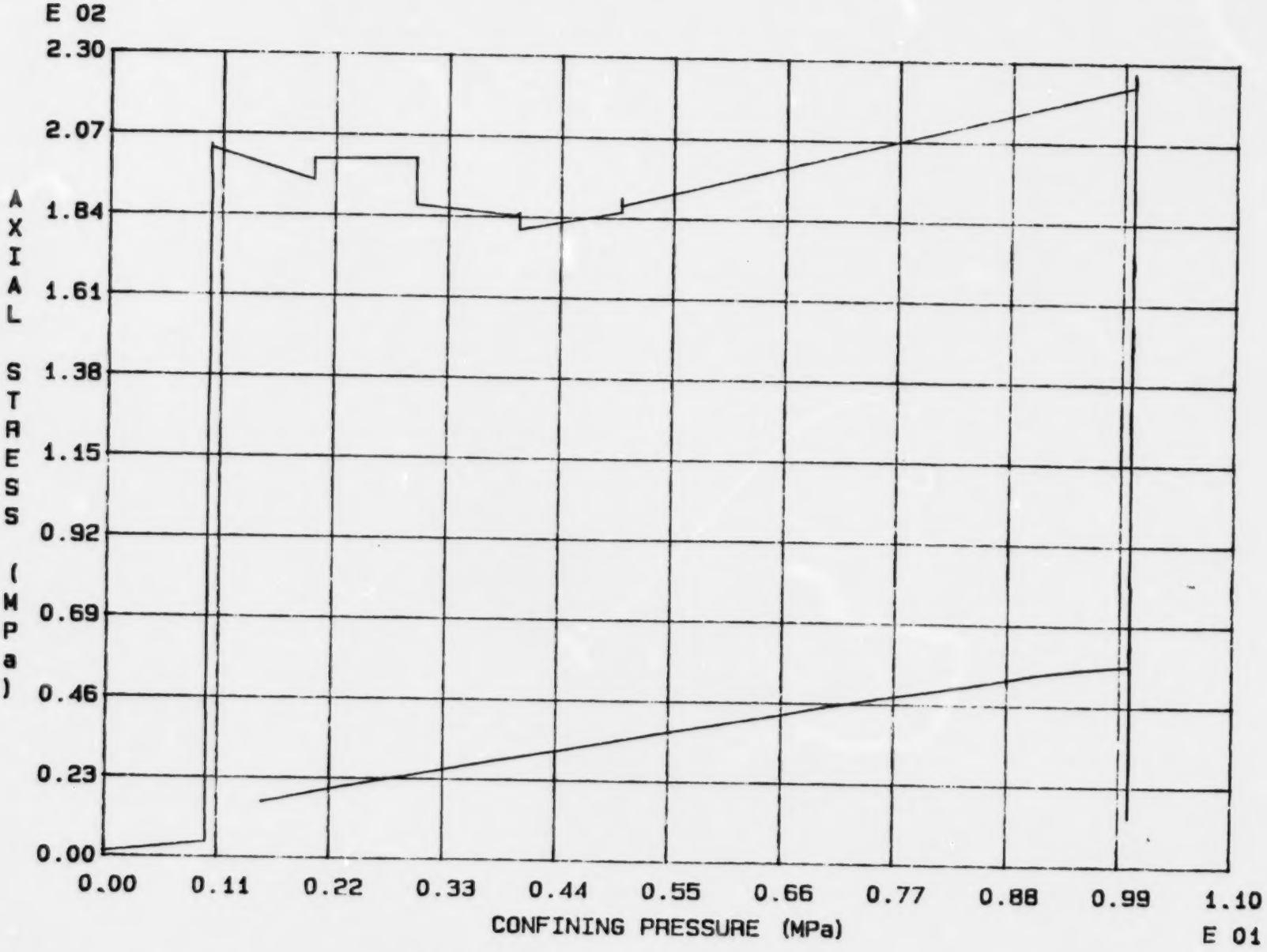

E 02
2.30
2.07
1.84
1.61
1.38
1.15
0.92
0.69
0.46
0.23
0.00
AXIAL STRESS (MPa)
0.00
0.11
0.22
0.33
0.44
0.55
0.66
0.77
0.88
0.99
1.10
E 01
CONFINING PRESSURE (MPa)

Fig. G-18 E36T

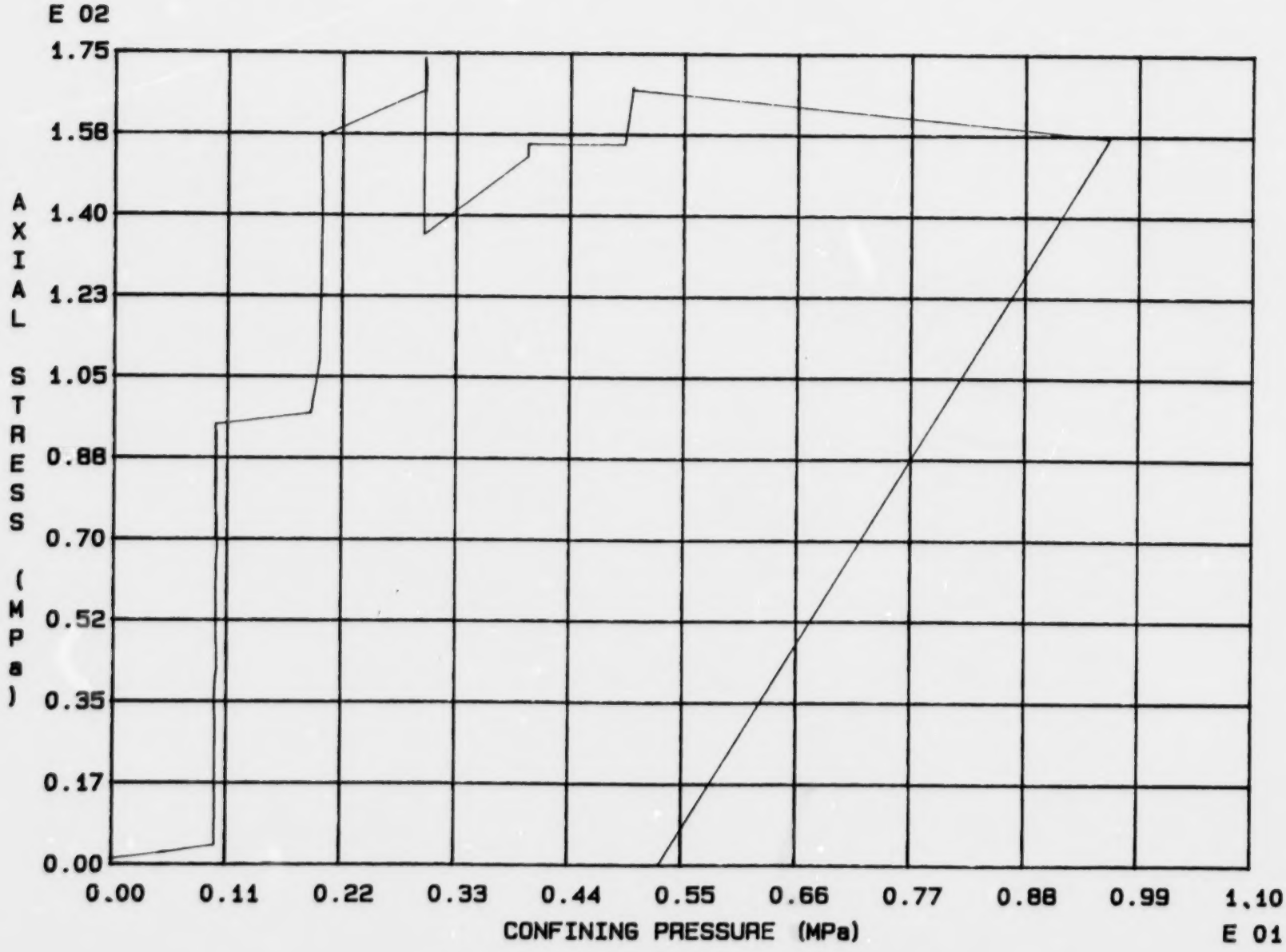

E 02
1.75
1.58
1.40
1.23
1.05
0.88
0.70
0.52
0.35
0.17
0.00
AXIAL STRESS (MPa)
0.00
0.11
0.22
0.33
0.44
0.55
0.66
0.77
0.88
0.99
1.10
CONFINING PRESSURE (MPa)
E 01

Fig. G-19 E38T

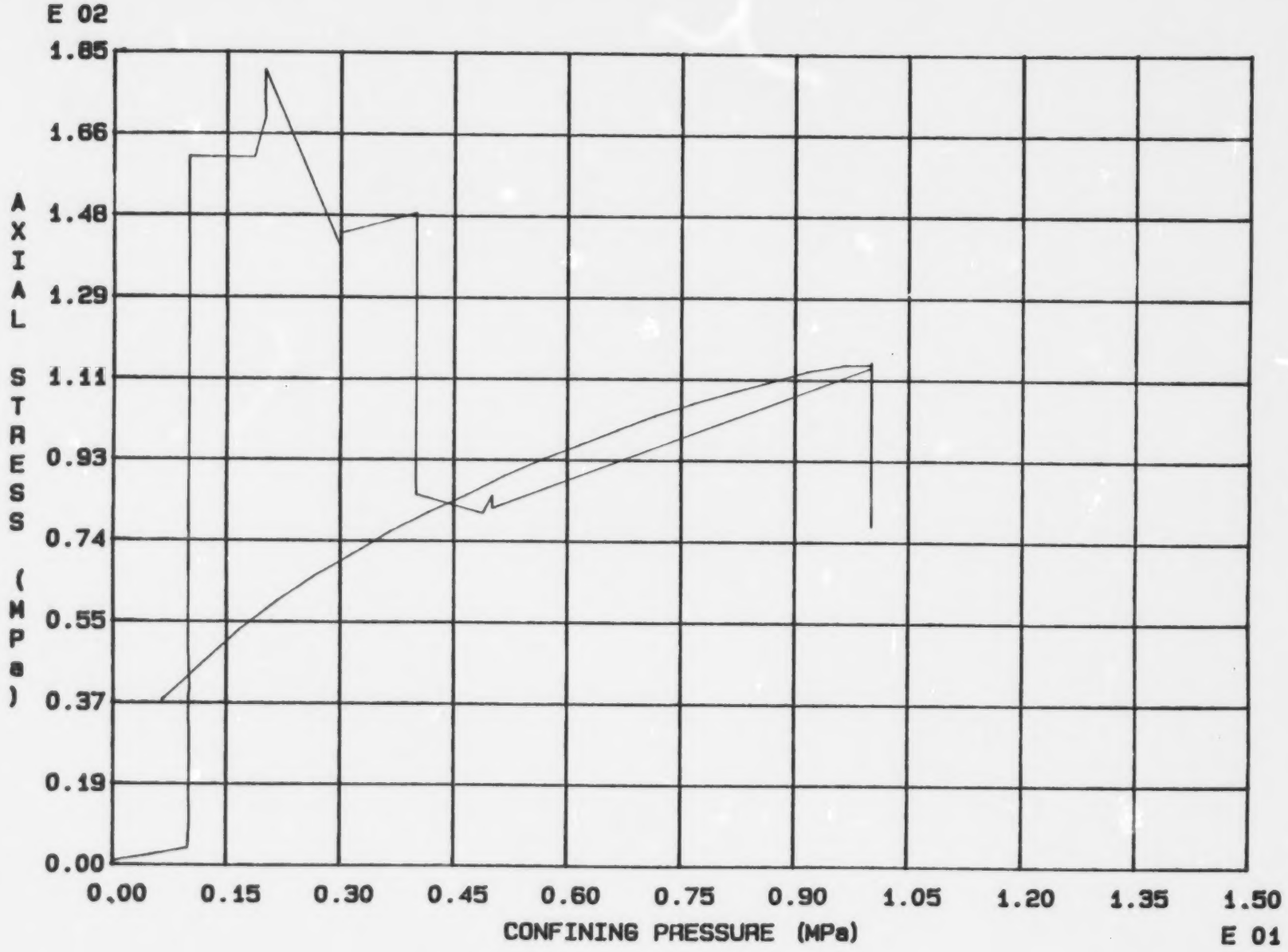

E 02
1.85
1.66
1.48
1.29
1.11
0.93
0.74
0.55
0.37
0.19
0.00
AXIAL STRESS (MPa)
0.00
0.15
0.30
0.45
0.60
0.75
0.90
1.05
1.20
1.35
1.50
CONFINING PRESSURE (MPa)
E 01

Fig. 6-20 E40T

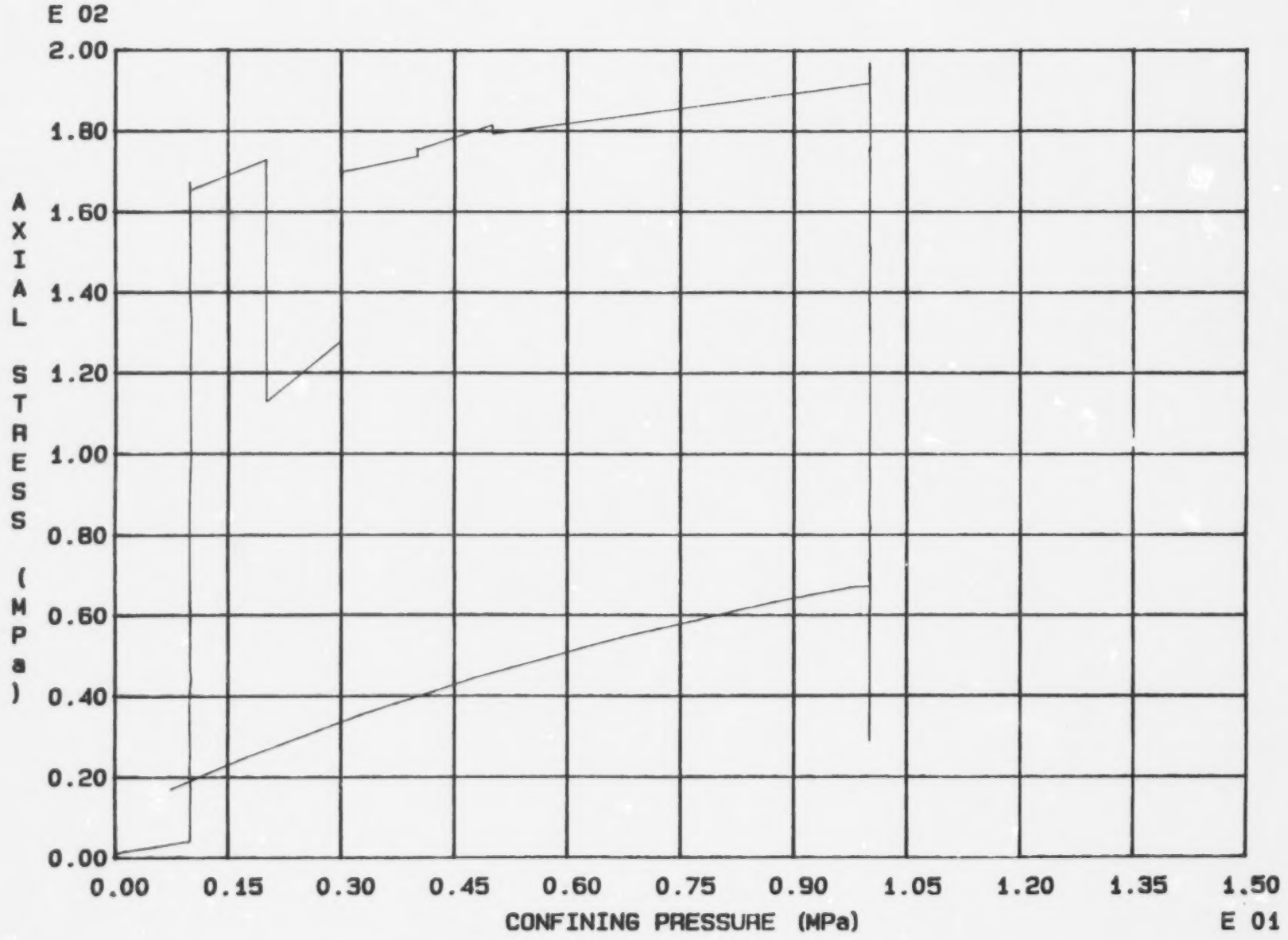

E 02
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
AXIAL STRESS (MPa)
0.00
0.15
0.30
0.45
0.60
0.75
0.90
1.05
1.20
1.35
1.50
CONFINING PRESSURE (MPa)
E 01

Fig. 6-21 E42T

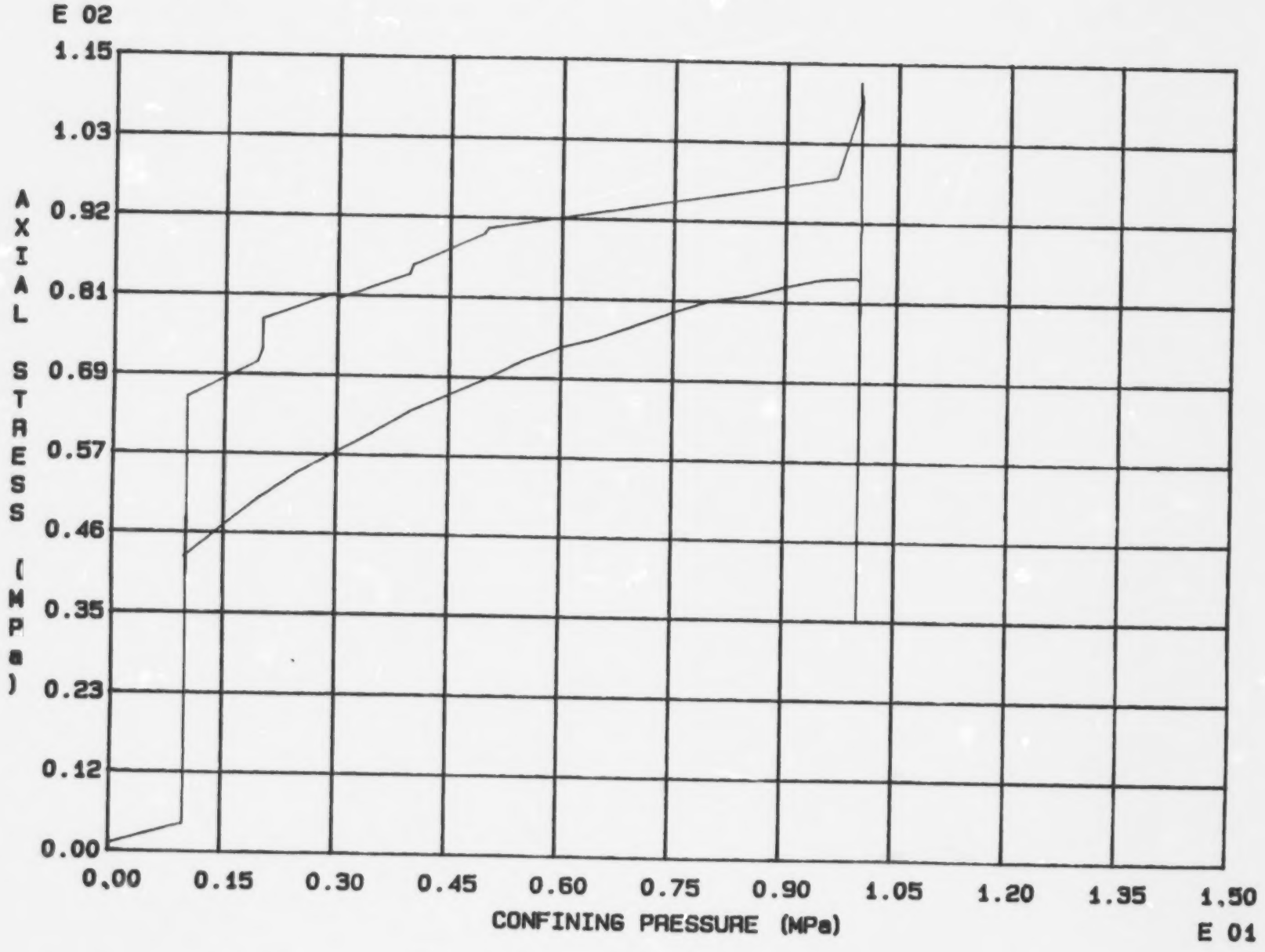

E 02
1.15
1.03
0.92
0.81
0.69
0.57
0.46
0.35
0.23
0.12
0.00
AXIAL STRESS (MPa)
0.00
0.15
0.30
0.45
0.60
0.75
0.90
1.05
1.20
1.35
1.50
CONFINING PRESSURE (MPa)
E 01

Fig. 6-22 E44T

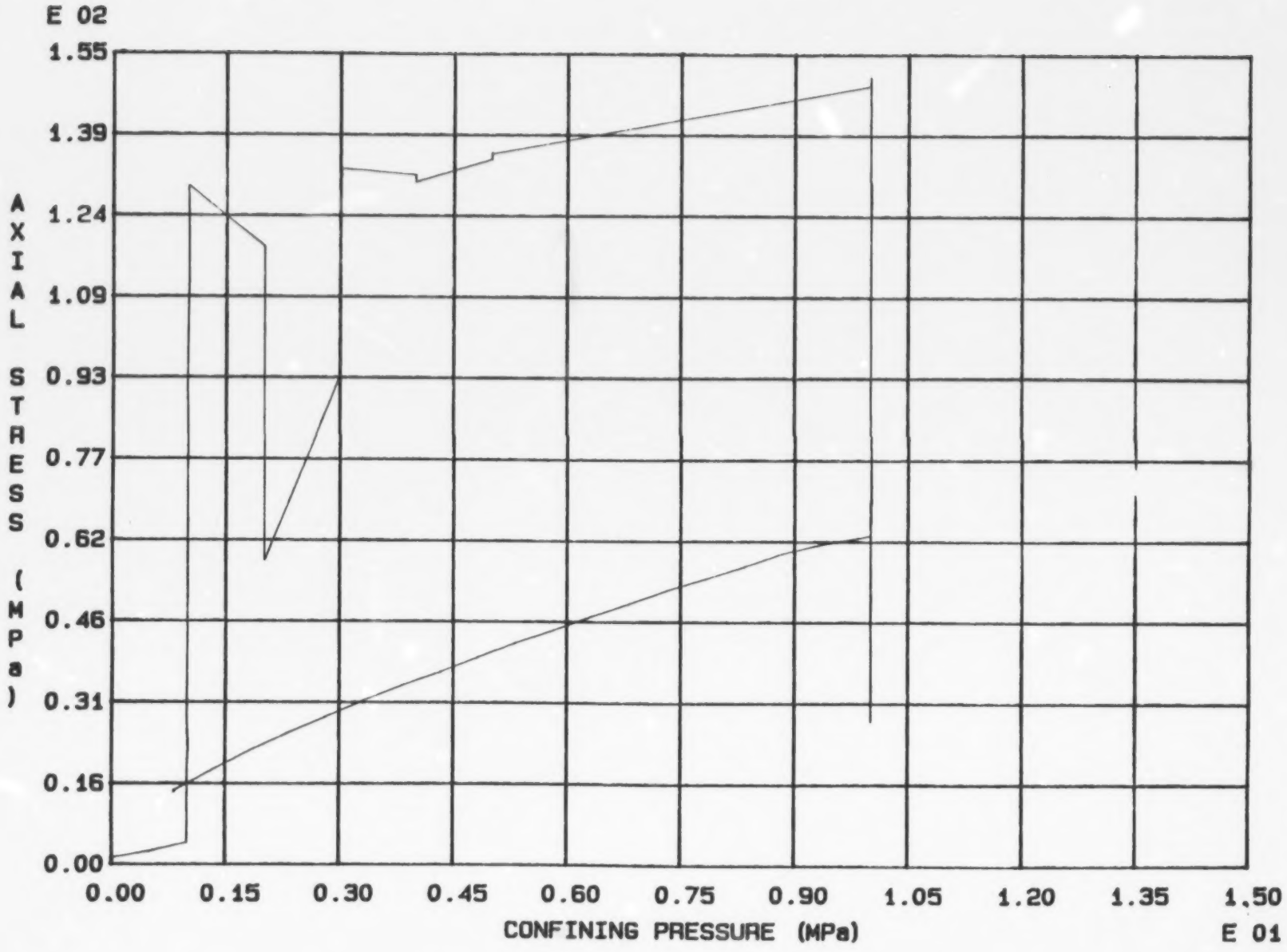

E 02
1.55
1.39
1.24
1.09
0.93
0.77
0.62
0.46
0.31
0.16
0.00
AXIAL STRESS (MPa)
0.00
0.15
0.30
0.45
0.60
0.75
0.90
1.05
1.20
1.35
1.50
CONFINING PRESSURE (MPa)
E 01

Fig. G-23 E46T

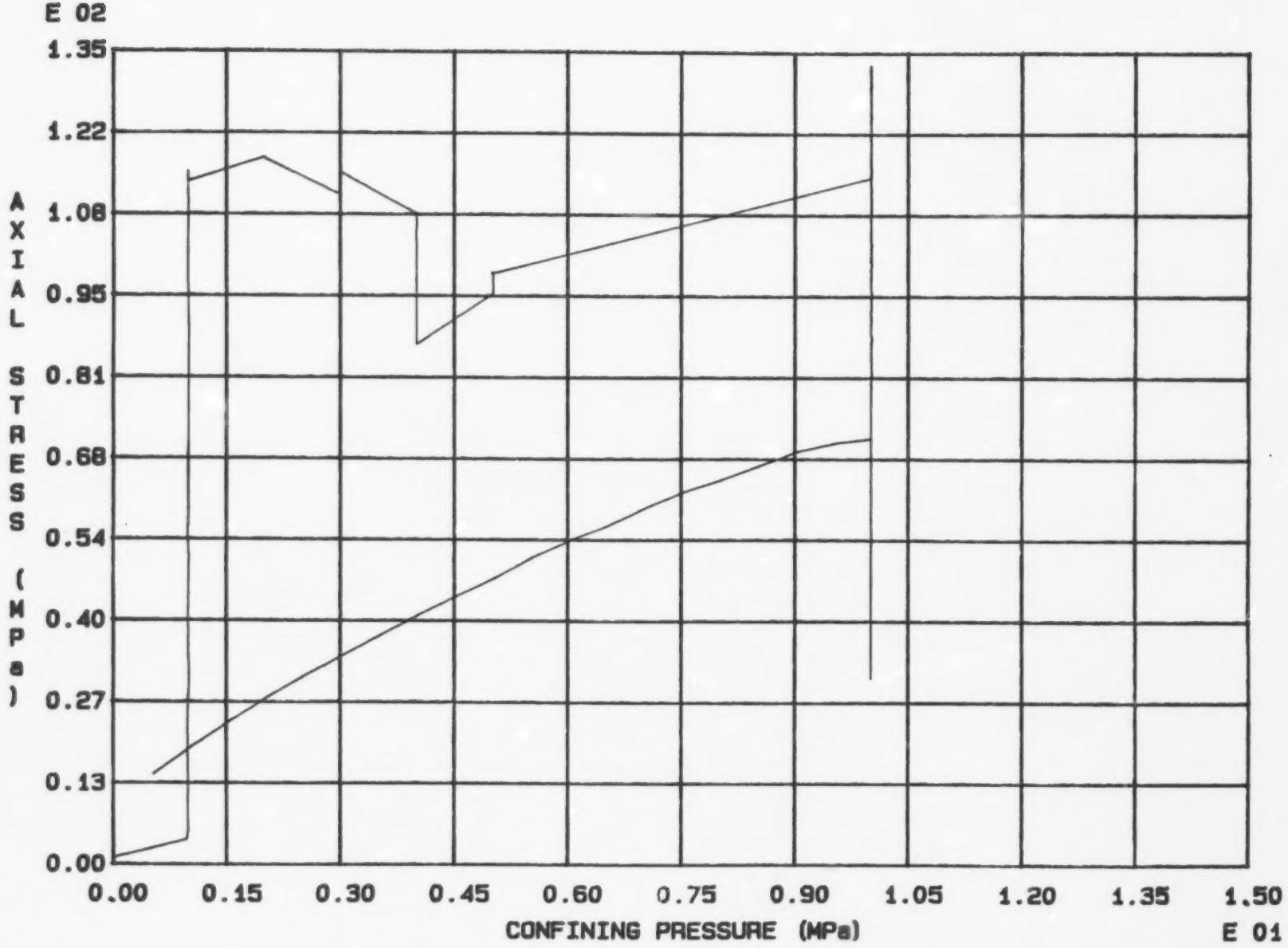

E 02
1.35
1.22
1.08
0.95
0.81
0.68
0.54
0.40
0.27
0.13
0.00
AXIAL STRESS (MPa)
0.00
0.15
0.30
0.45
0.60
0.75
0.90
1.05
1.20
1.35
1.50
CONFINING PRESSURE (MPa)
E 01

Fig. G-24 E48T

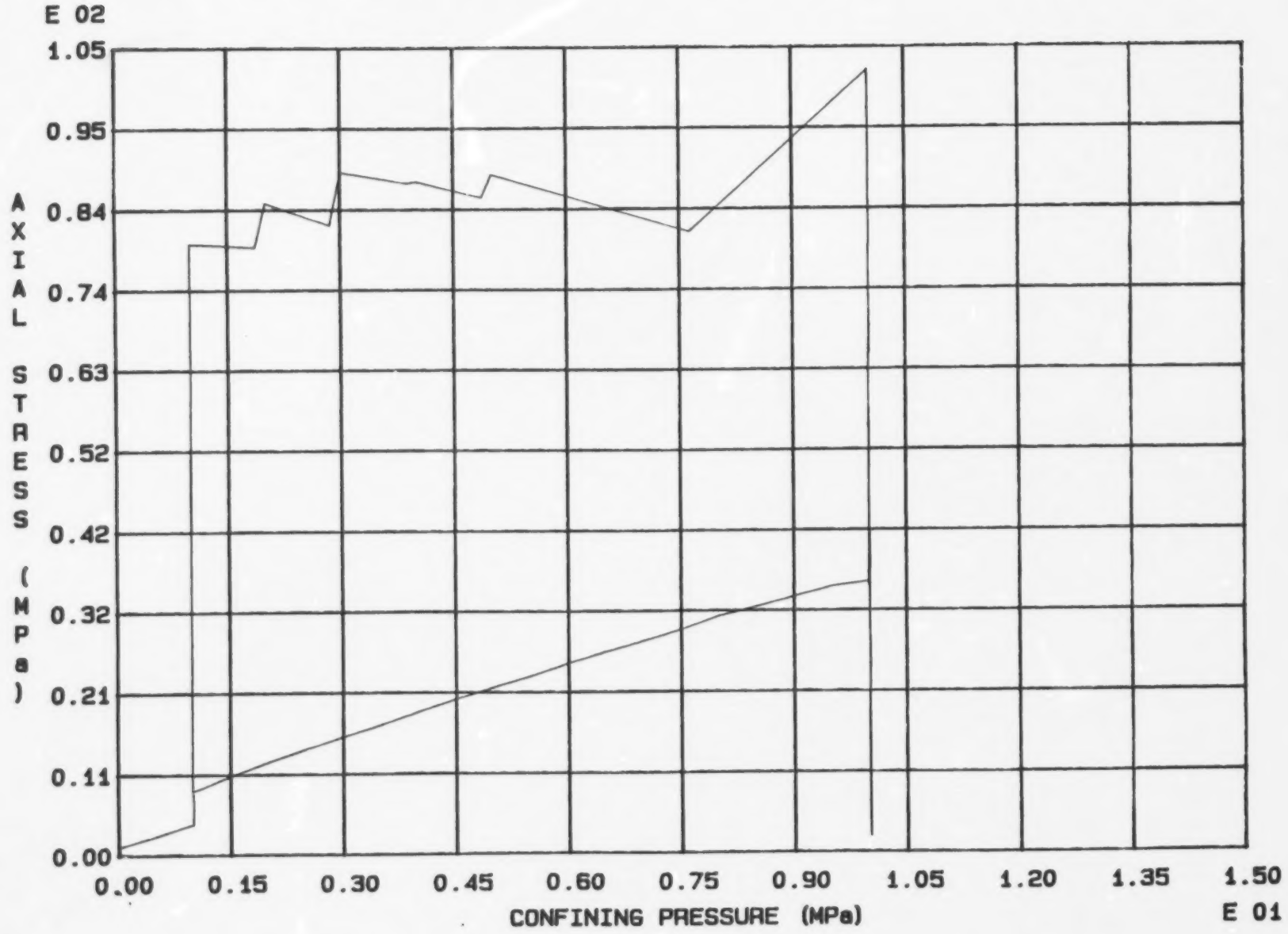

E 02
1.05
0.95
0.84
0.74
0.63
0.52
0.42
0.32
0.21
0.11
0.00
AXIAL STRESS (MPa)
0.00
0.15
0.30
0.45
0.60
0.75
0.90
1.05
1.20
1.35
1.50
CONFINING PRESSURE (MPa)
E 01

Fig. 6-25 E50T

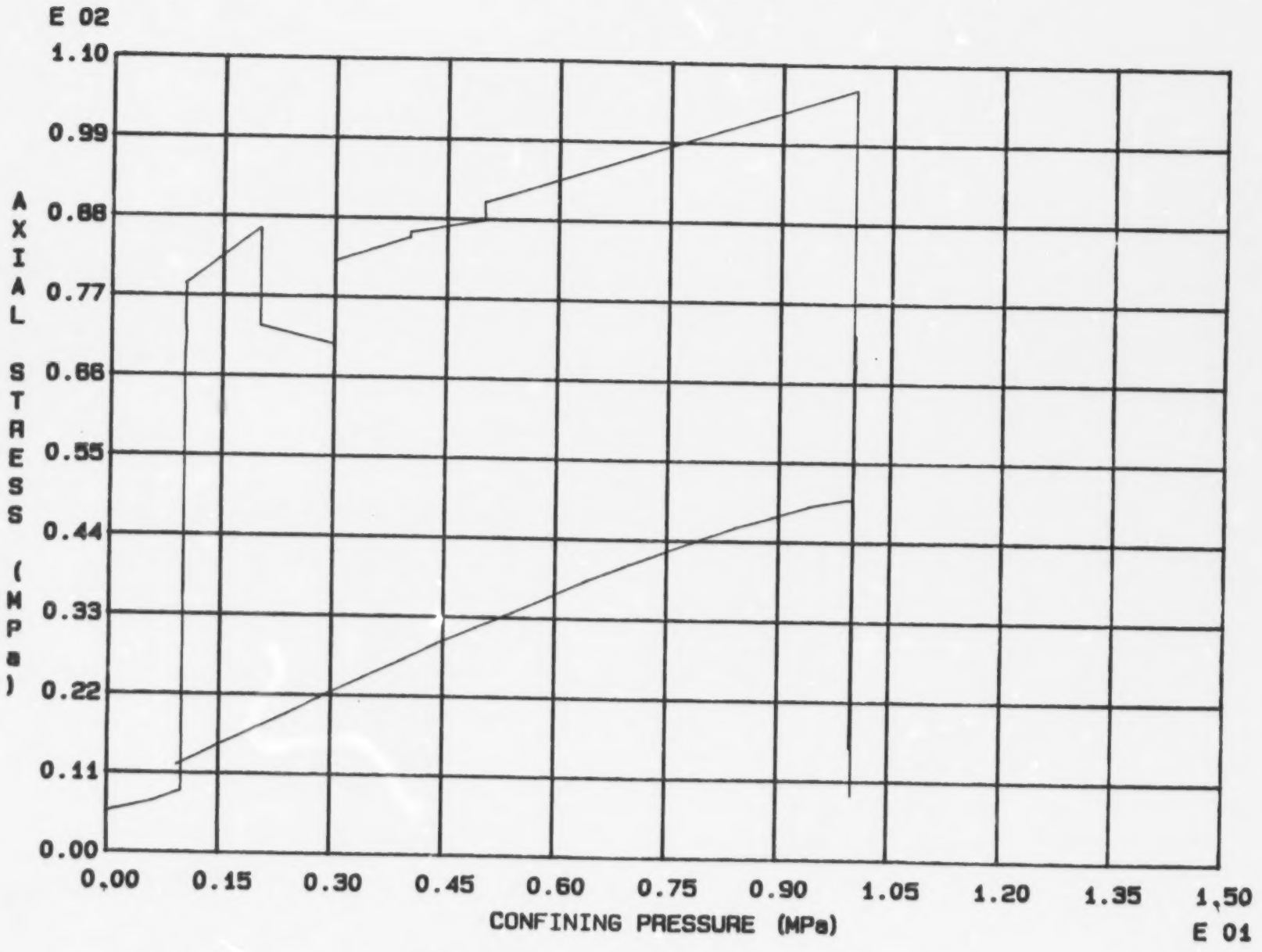

E 02
1.10
0.99
0.88
0.77
0.66
0.55
0.44
0.33
0.22
0.11
0.00
AXIAL STRESS (MPa)
0.00
0.15
0.30
0.45
0.60
0.75
0.90
1.05
1.20
1.35
1.50
E 01
CONFINING PRESSURE (MPa)

Fig. G-26 E52T

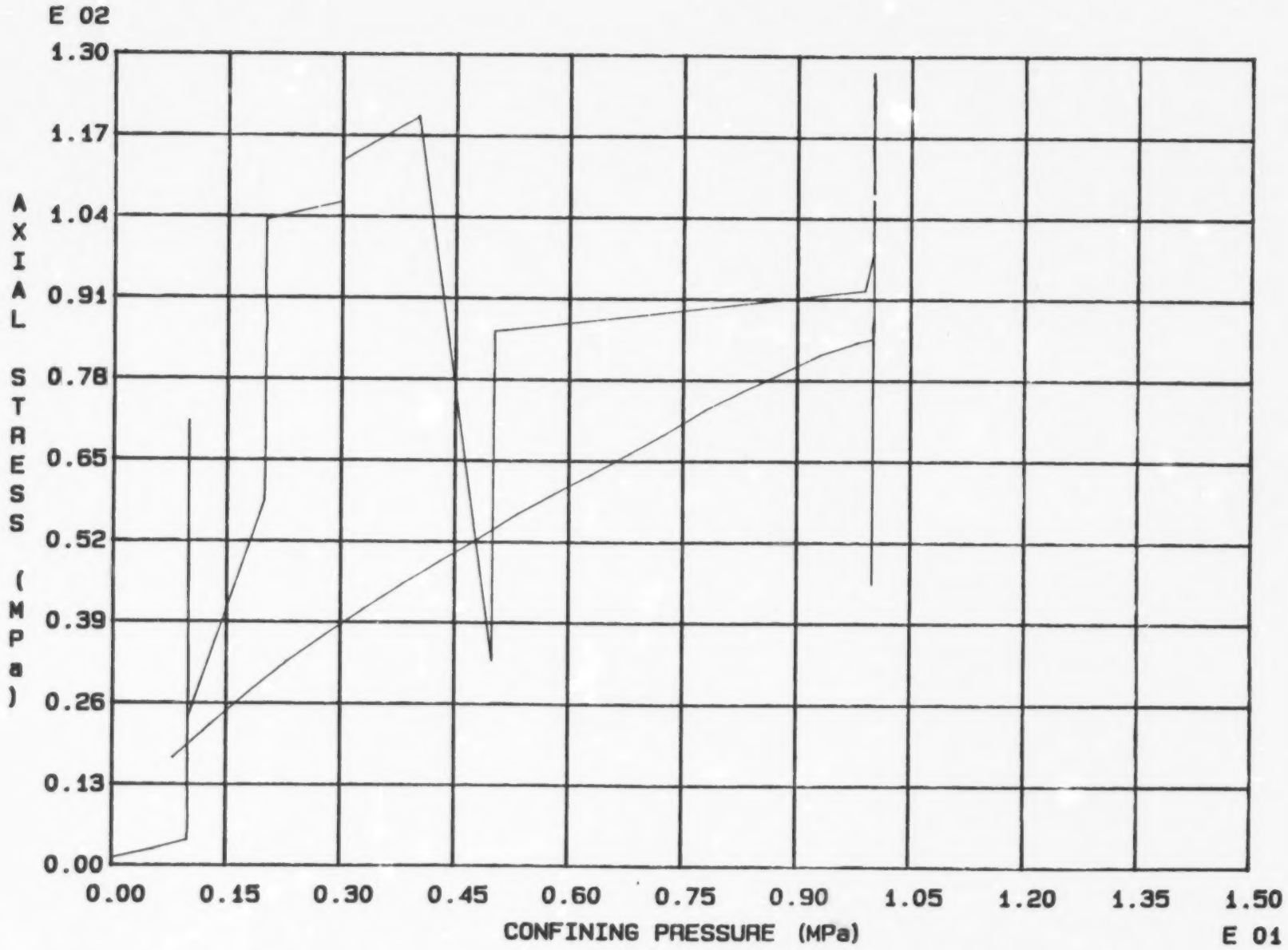

E 02
1.30
1.17
1.04
0.91
0.78
0.65
0.52
0.39
0.26
0.13
0.00
AXIAL STRESS (MPa)
0.00
0.15
0.30
0.45
0.60
0.75
0.90
1.05
1.20
1.35
1.50
CONFINING PRESSURE (MPa)
E 01

Fig. 6-27 E56T

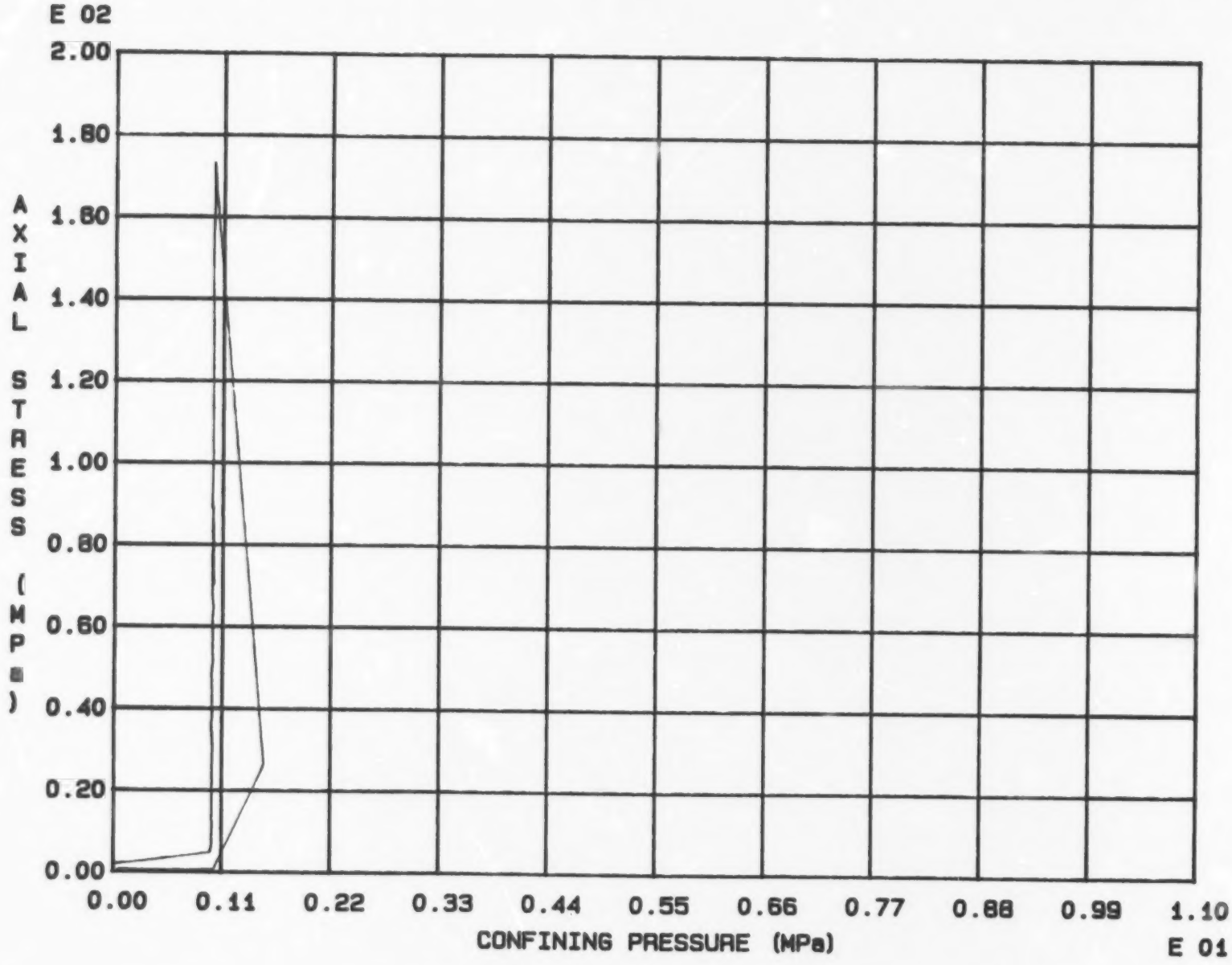

E 02
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
AXIAL STRESS (MPa)
0.00
0.11
0.22
0.33
0.44
0.55
0.66
0.77
0.88
0.99
1.10
CONFINING PRESSURE (MPa)
E 01

Fig. G-28 E61M

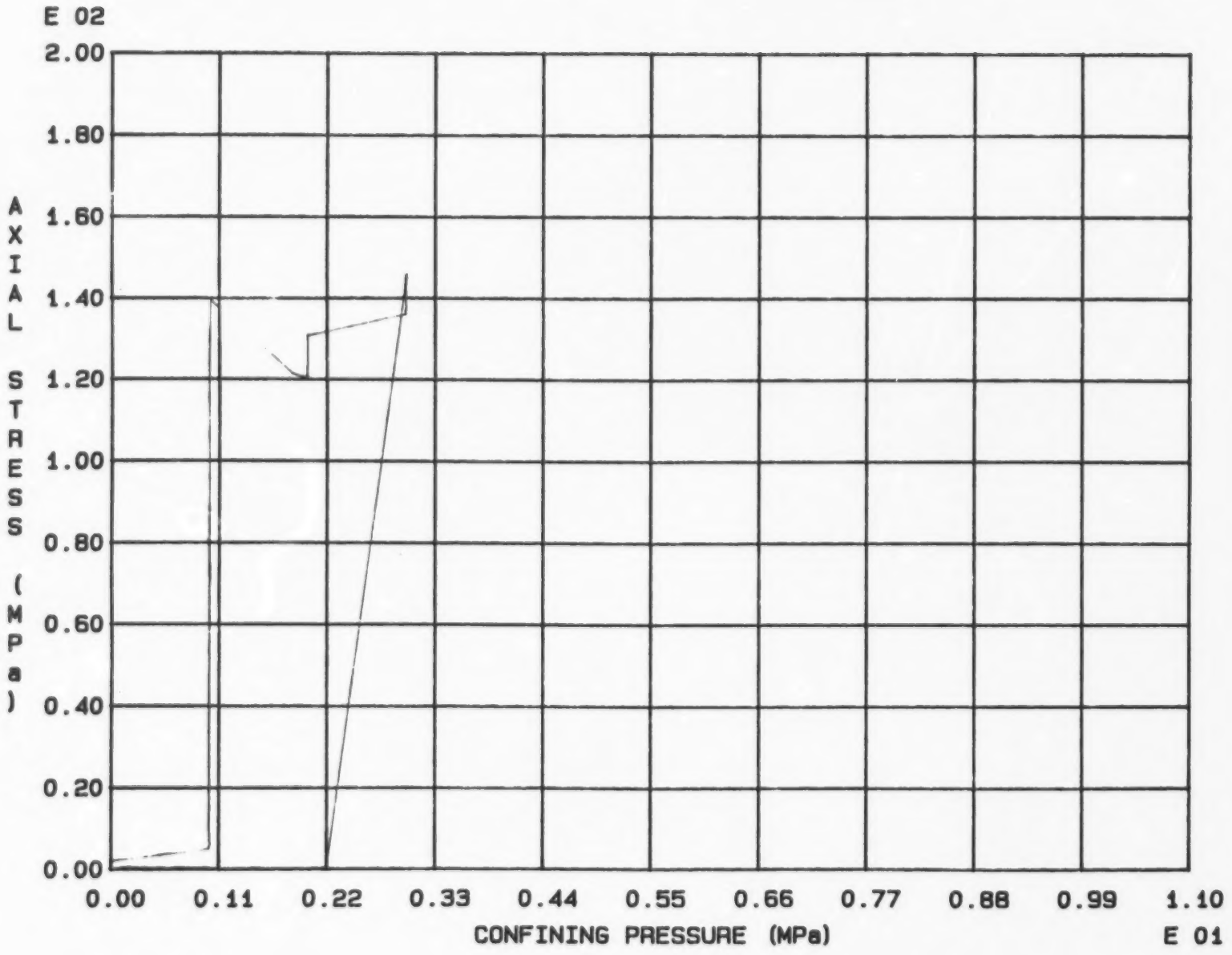

E 02
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
AXIAL STRESS (MPa)
0.00
0.11
0.22
0.33
0.44
0.55
0.66
0.77
0.88
0.99
1.10
CONFINING PRESSURE (MPa)
E 01

Fig. 6-29 E62M

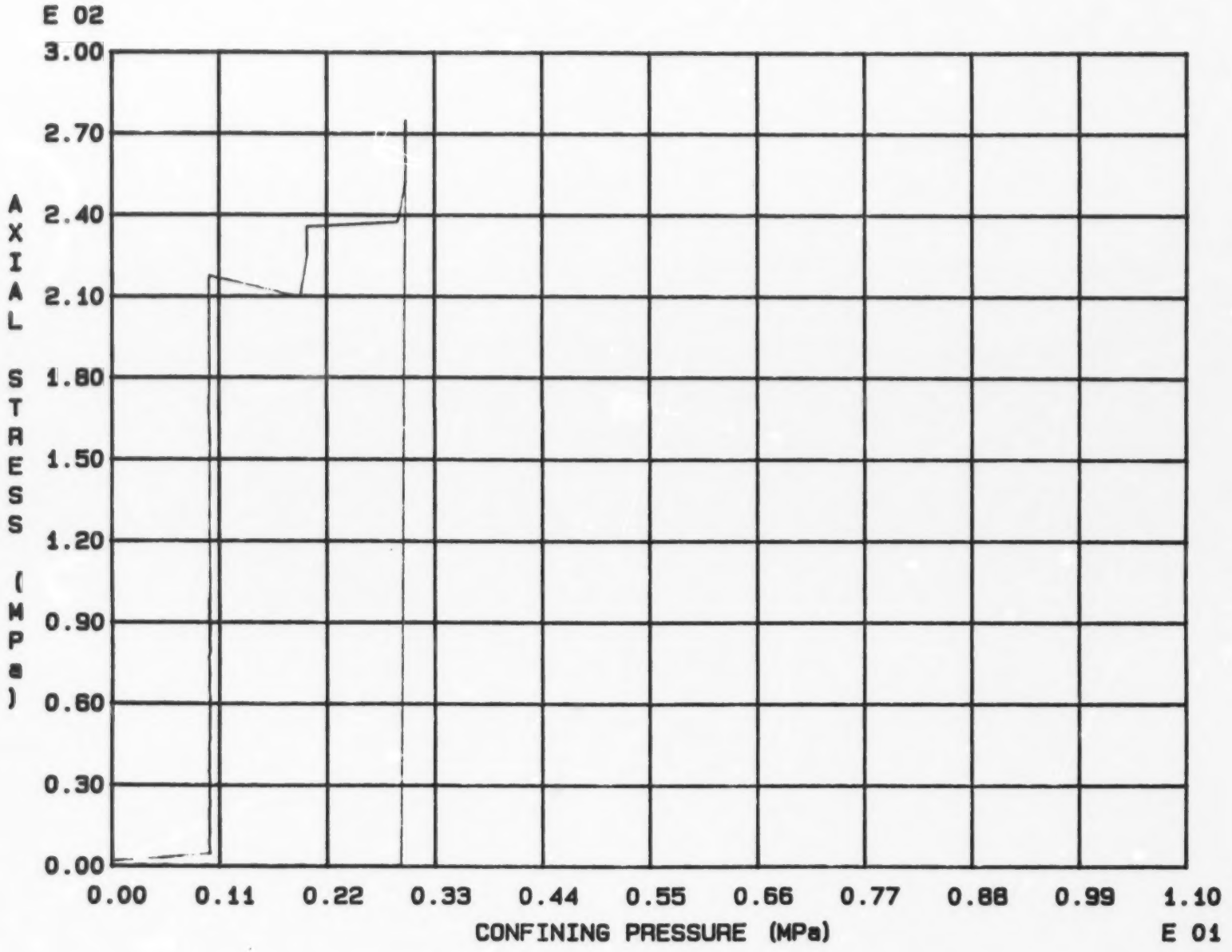

E 02
3.00
2.70
2.40
2.10
1.80
1.50
1.20
0.90
0.60
0.30
0.00
AXIAL STRESS (MPa)
0.00
0.11
0.22
0.33
0.44
0.55
0.66
0.77
0.88
0.99
1.10
CONFINING PRESSURE (MPa)
E 01

Fig. 6-30 E63M

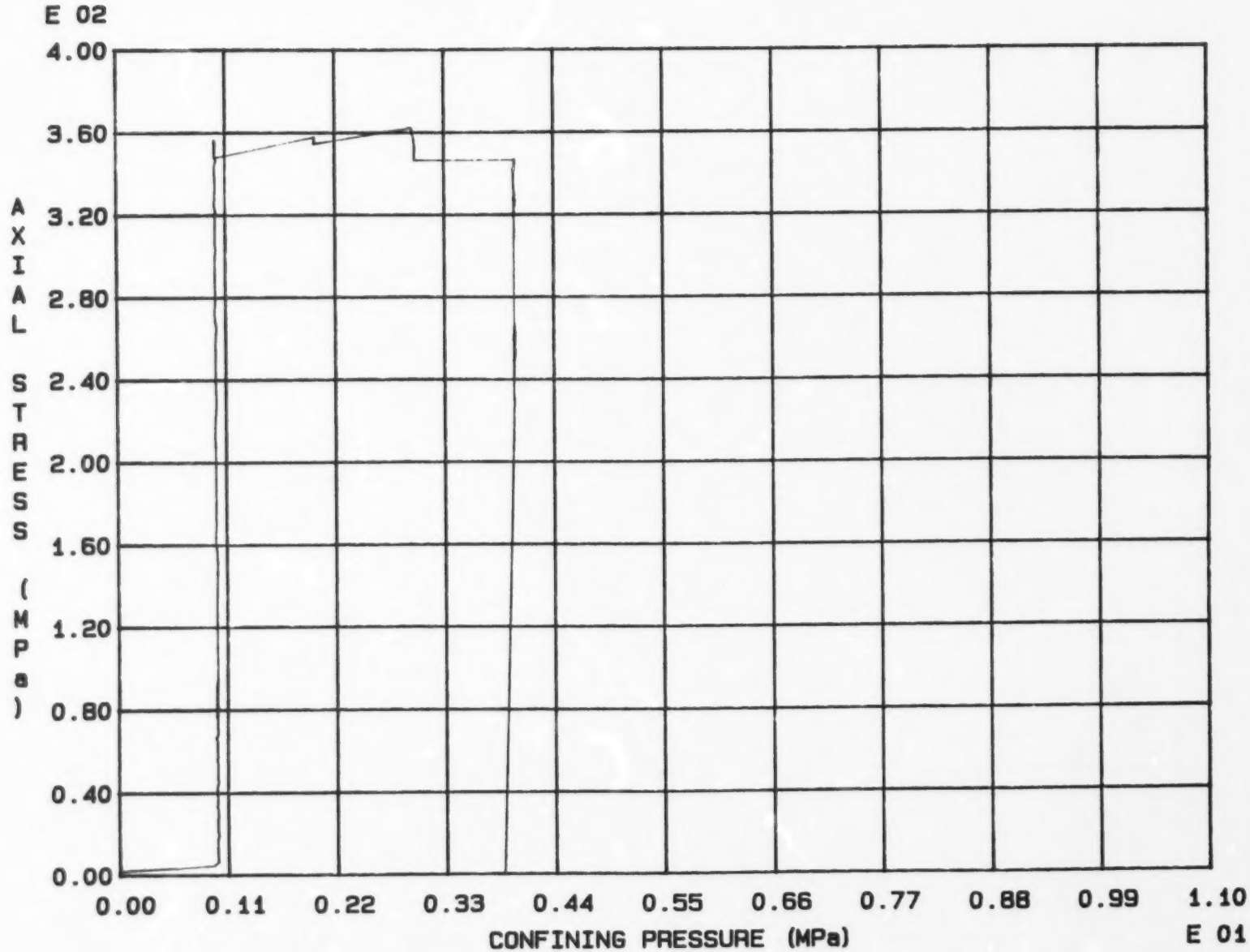

E 02
4.00
3.60
3.20
2.80
2.40
2.00
1.60
1.20
0.80
0.40
0.00
AXIAL STRESS (MPa)
0.00
0.11
0.22
0.33
0.44
0.55
0.66
0.77
0.88
0.99
1.10
E 01
CONFINING PRESSURE (MPa)

Fig. 6-31 E64M

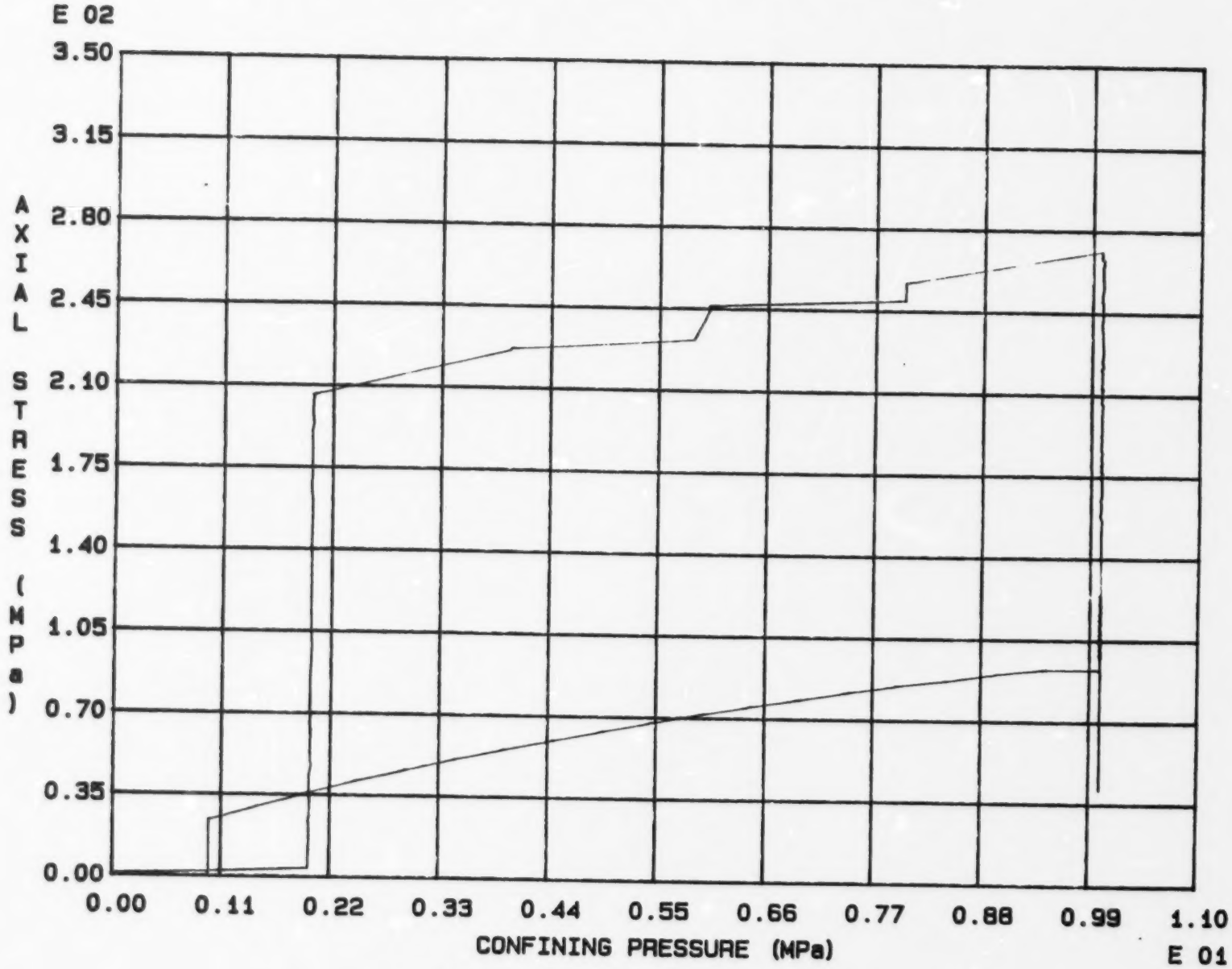

E 02
3.50
3.15
2.80
2.45
2.10
1.75
1.40
1.05
0.70
0.35
0.00
AXIAL STRESS (MPa)
0.00
0.11
0.22
0.33
0.44
0.55
0.66
0.77
0.88
0.99
1.10
E 01
CONFINING PRESSURE (MPa)

Fig. 6-32 E65M

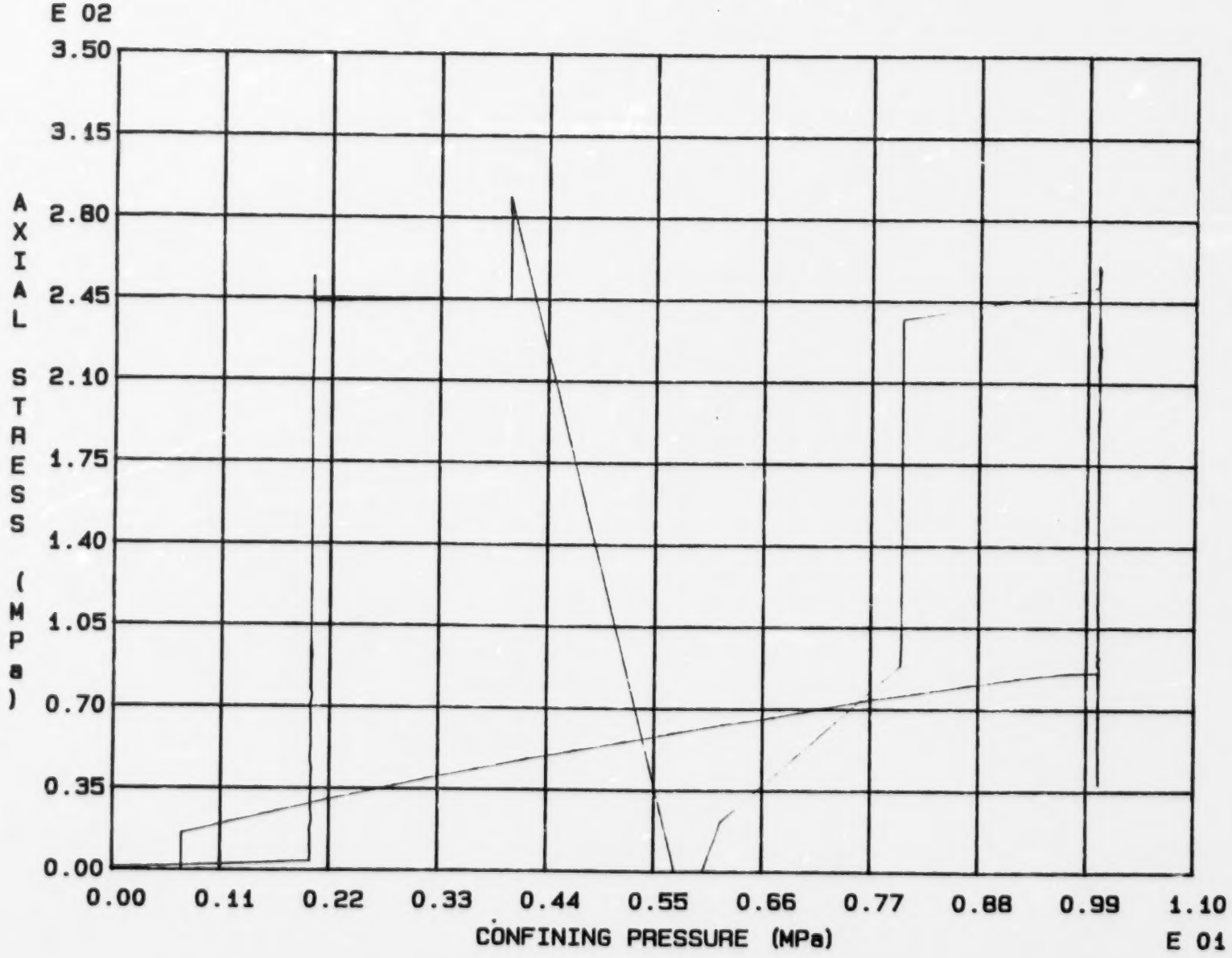

E 02
3.50
3.15
2.80
2.45
2.10
1.75
1.40
1.05
0.70
0.35
0.00
AXIAL STRESS (MPa)
0.00
0.11
0.22
0.33
0.44
0.55
0.66
0.77
0.88
0.99
1.10
CONFINING PRESSURE (MPa)
E 01

Fig. 6-33 E66M

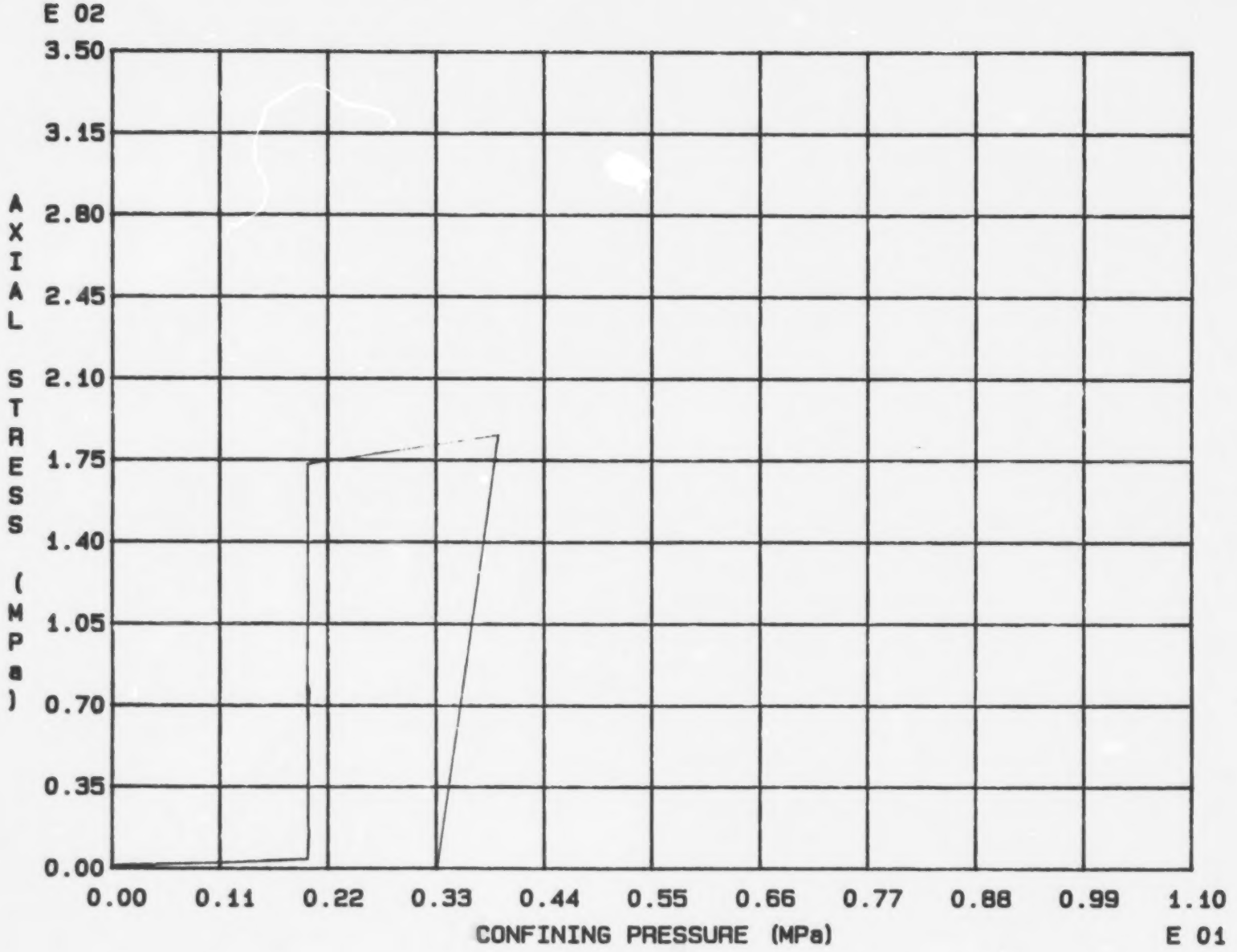

E 02
3.50
3.15
2.80
2.45
2.10
1.75
1.40
1.05
0.70
0.35
0.00
AXIAL STRESS (MPa)
0.00
0.11
0.22
0.33
0.44
0.55
0.66
0.77
0.88
0.99
1.10
CONFINING PRESSURE (MPa)
E 01

Fig. 8-34 E67M

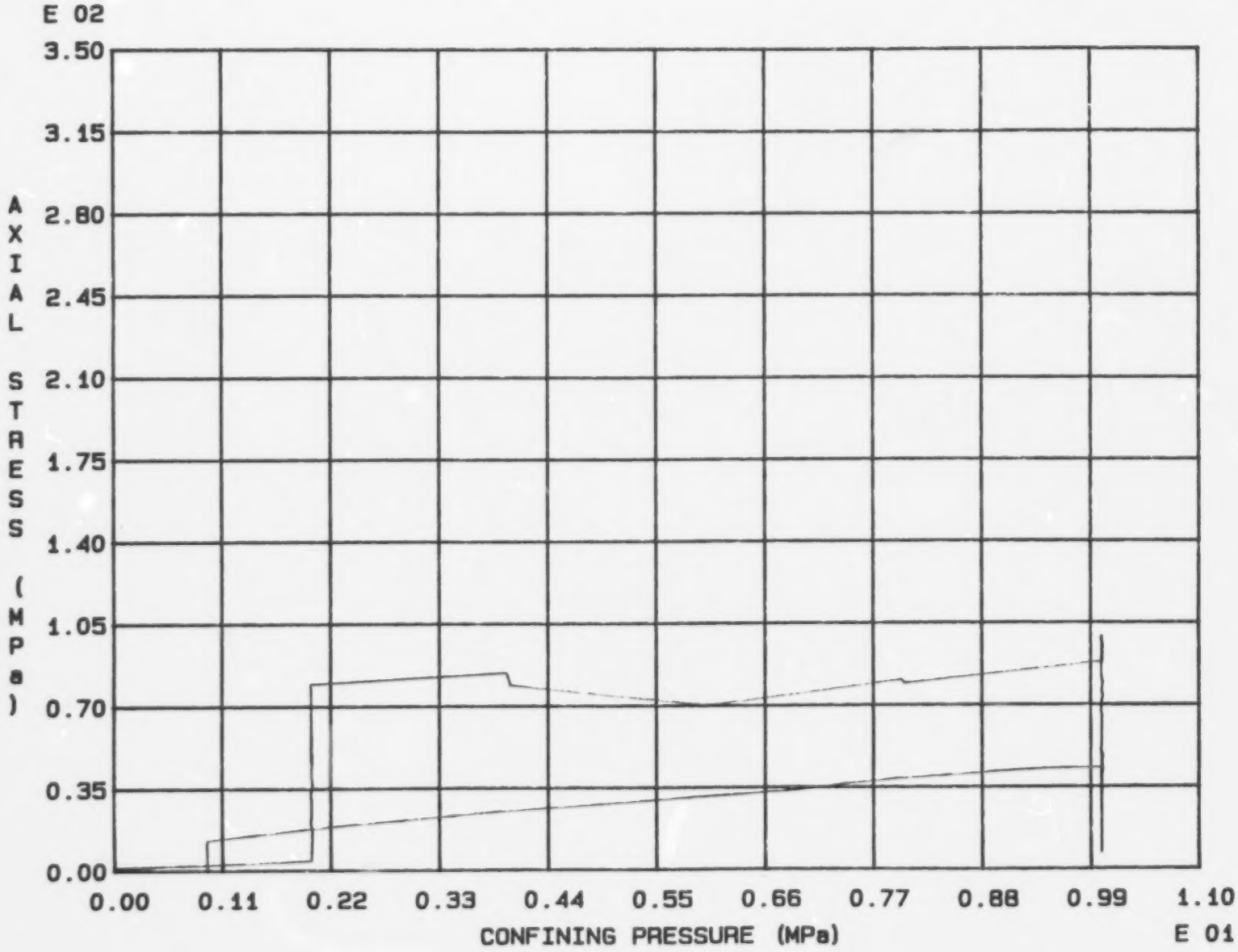

E 02
3.50
3.15
2.80
2.45
2.10
1.75
1.40
1.05
0.70
0.35
0.00
AXIAL STRESS (MPa)
0.00
0.11
0.22
0.33
0.44
0.55
0.66
0.77
0.88
0.99
1.10
CONFINING PRESSURE (MPa)
E 01

Fig. 6-35 E68M

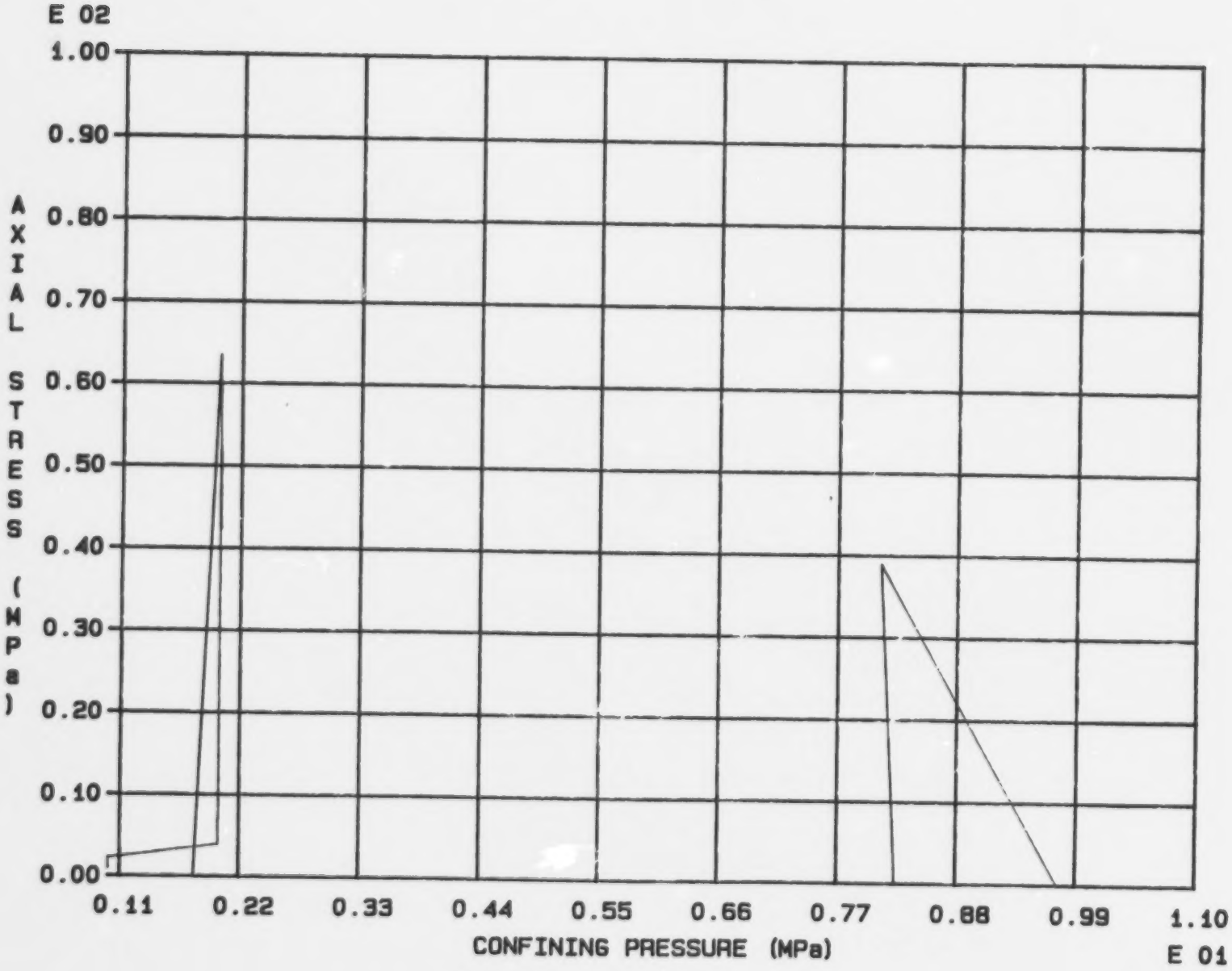

E 02
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
AXIAL STRESS (MPa)
0.11
0.22
0.33
0.44
0.55
0.66
0.77
0.88
0.99
1.10
E 01
CONFINING PRESSURE (MPa)

Fig. 6-36 E69M

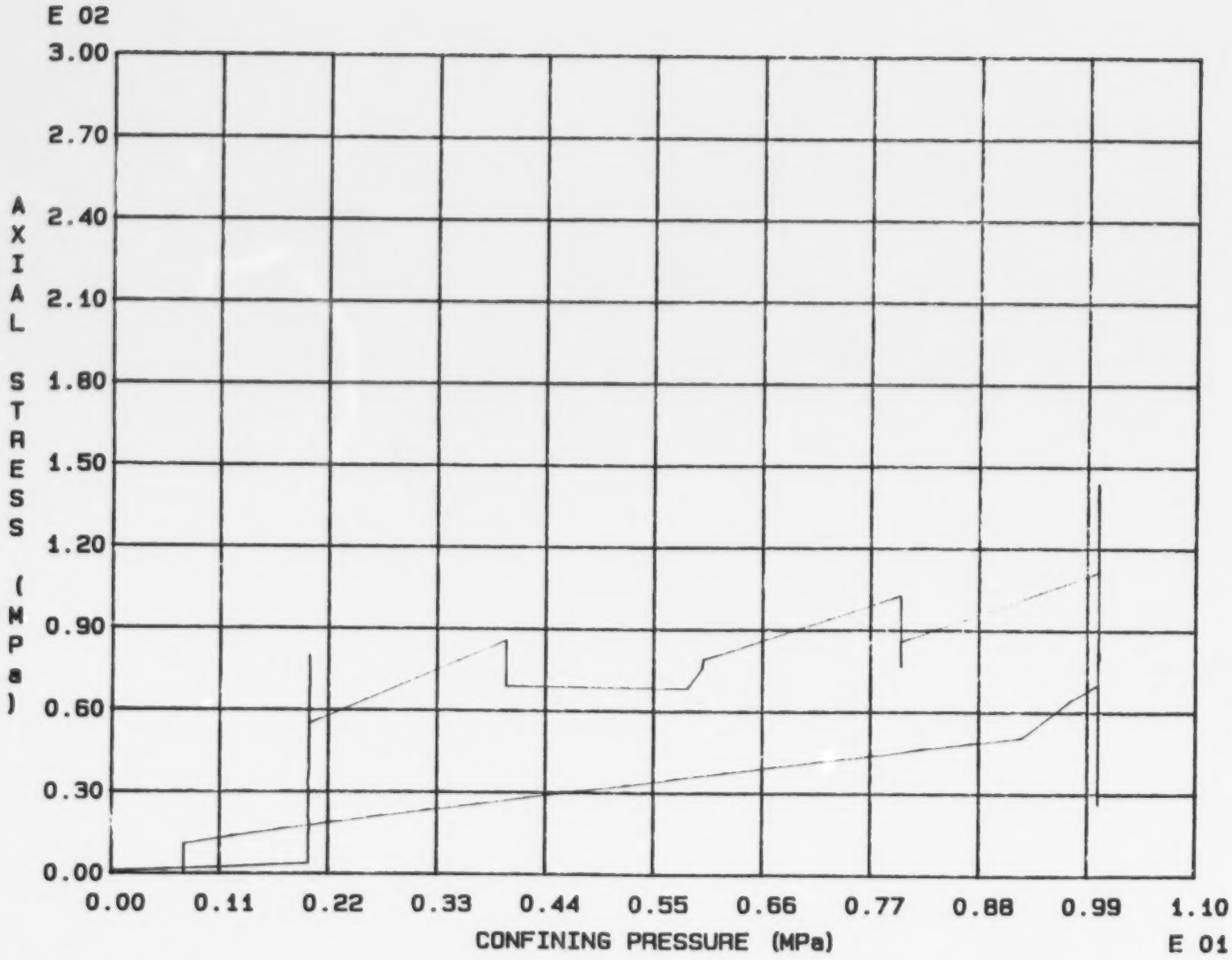

E 02
3.00
2.70
2.40
2.10
1.80
1.50
1.20
0.90
0.60
0.30
0.00
AXIAL STRESS (MPa)
0.00
0.11
0.22
0.33
0.44
0.55
0.66
0.77
0.88
0.99
1.10
CONFINING PRESSURE (MPa)
E 01

Fig. G-37 E70M

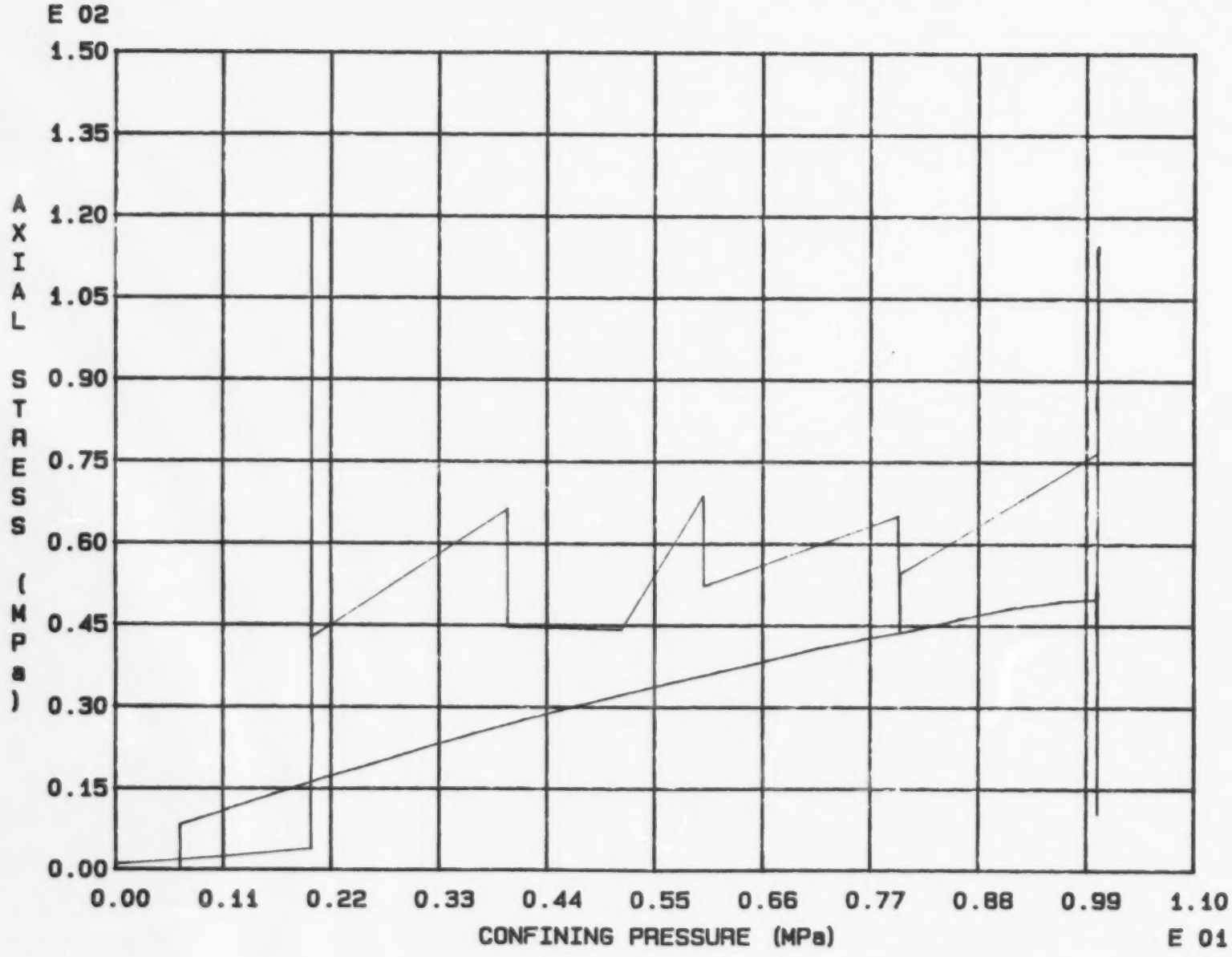

E 02
1.50
1.35
1.20
1.05
0.90
0.75
0.60
0.45
0.30
0.15
0.00
AXIAL STRESS (MPa)
0.00
0.11
0.22
0.33
0.44
0.55
0.66
0.77
0.88
0.99
1.10
CONFINING PRESSURE (MPa)
E 01

Fig. G-38 E71M

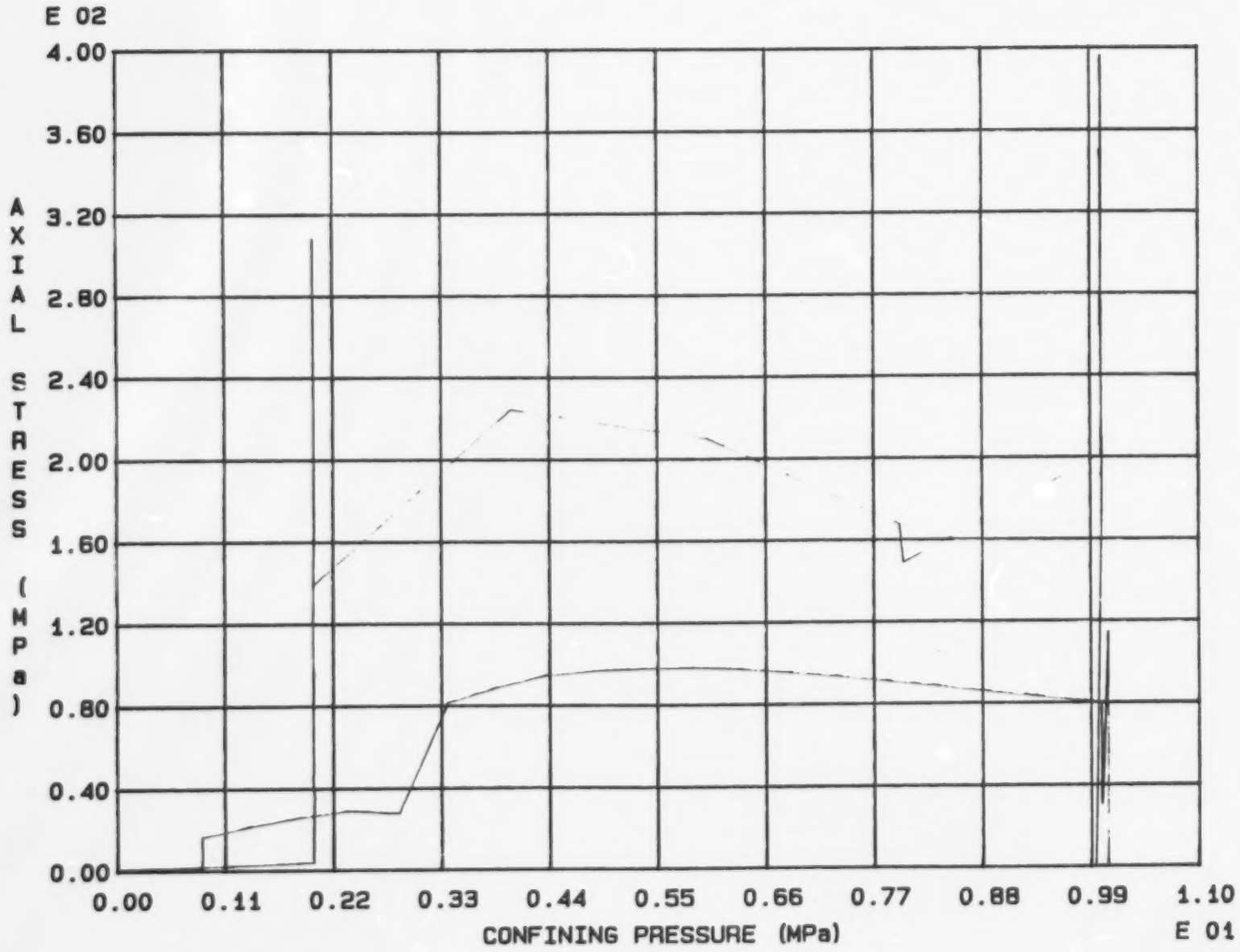

E 02
4.00
3.60
3.20
2.80
2.40
2.00
1.60
1.20
0.80
0.40
0.00
AXIAL STRESS (MPa)
0.00
0.11
0.22
0.33
0.44
0.55
0.66
0.77
0.88
0.99
1.10
E 01
CONFINING PRESSURE (MPa)

Fig. G-39 E92M

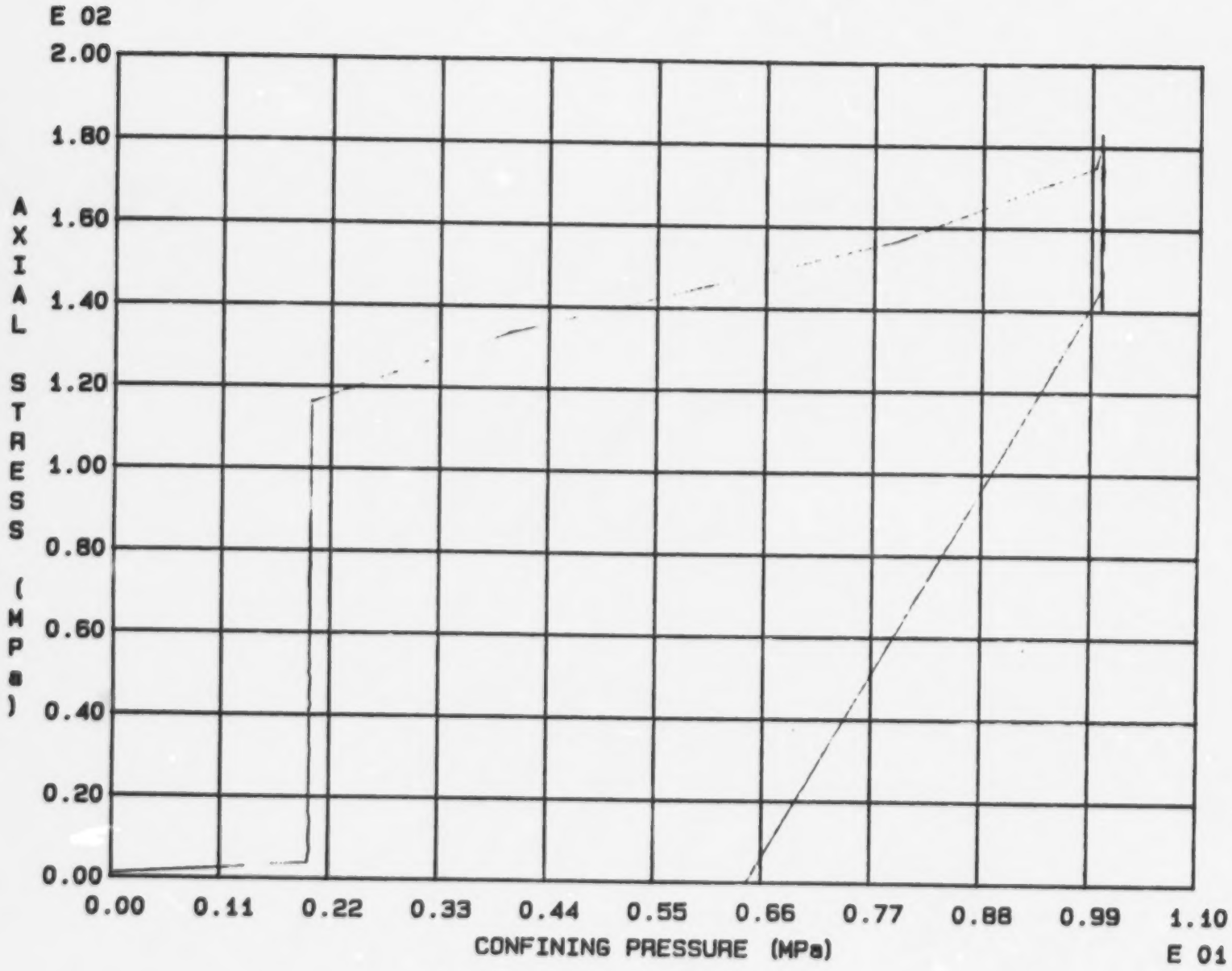

E 02
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
AXIAL STRESS (MPa)
0.00
0.11
0.22
0.33
0.44
0.55
0.66
0.77
0.88
0.99
1.10
CONFINING PRESSURE (MPa)
E 01

Fig. G-40 E93M

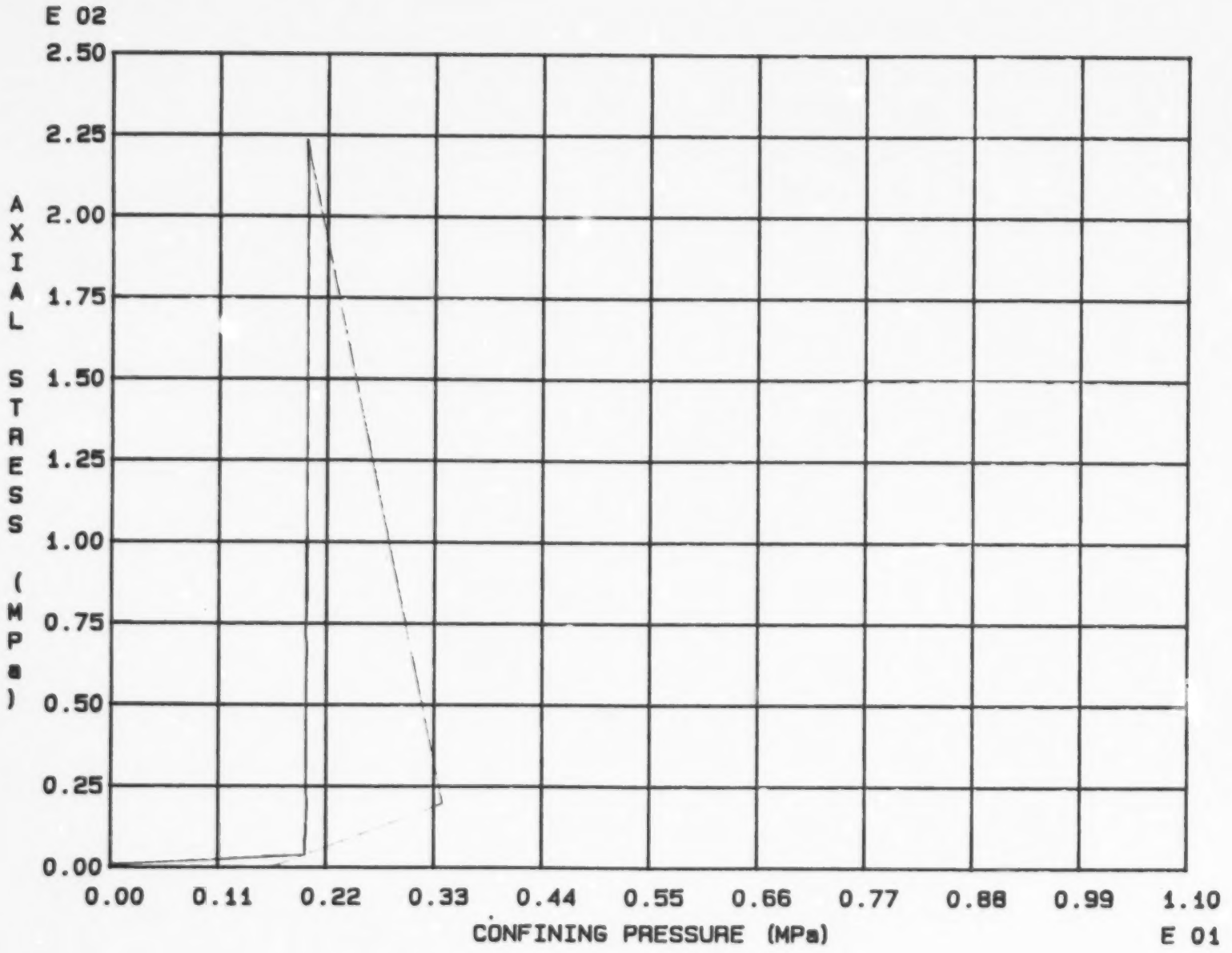

E 02
2.50
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
AXIAL STRESS (MPa)
0.00
0.11
0.22
0.33
0.44
0.55
0.66
0.77
0.88
0.99
1.10
CONFINING PRESSURE (MPa)
E 01

Fig. 6-41 E94M

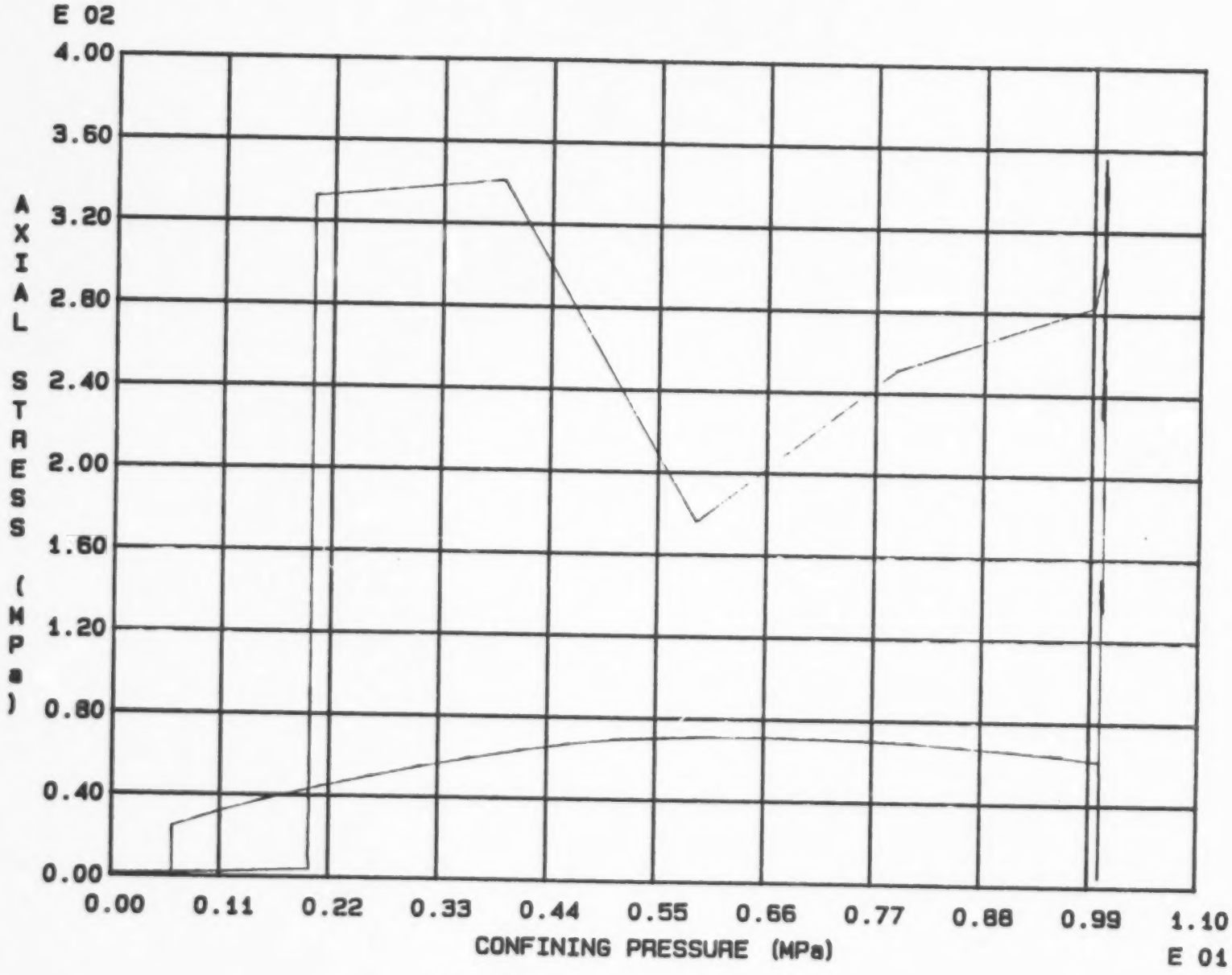

E 02
4.00
3.60
3.20
2.80
2.40
2.00
1.60
1.20
0.80
0.40
0.00
AXIAL STRESS (MPa)
0.00
0.11
0.22
0.33
0.44
0.55
0.66
0.77
0.88
0.99
1.10
E 01
CONFINING PRESSURE (MPa)

Fig. 8-42 E95M

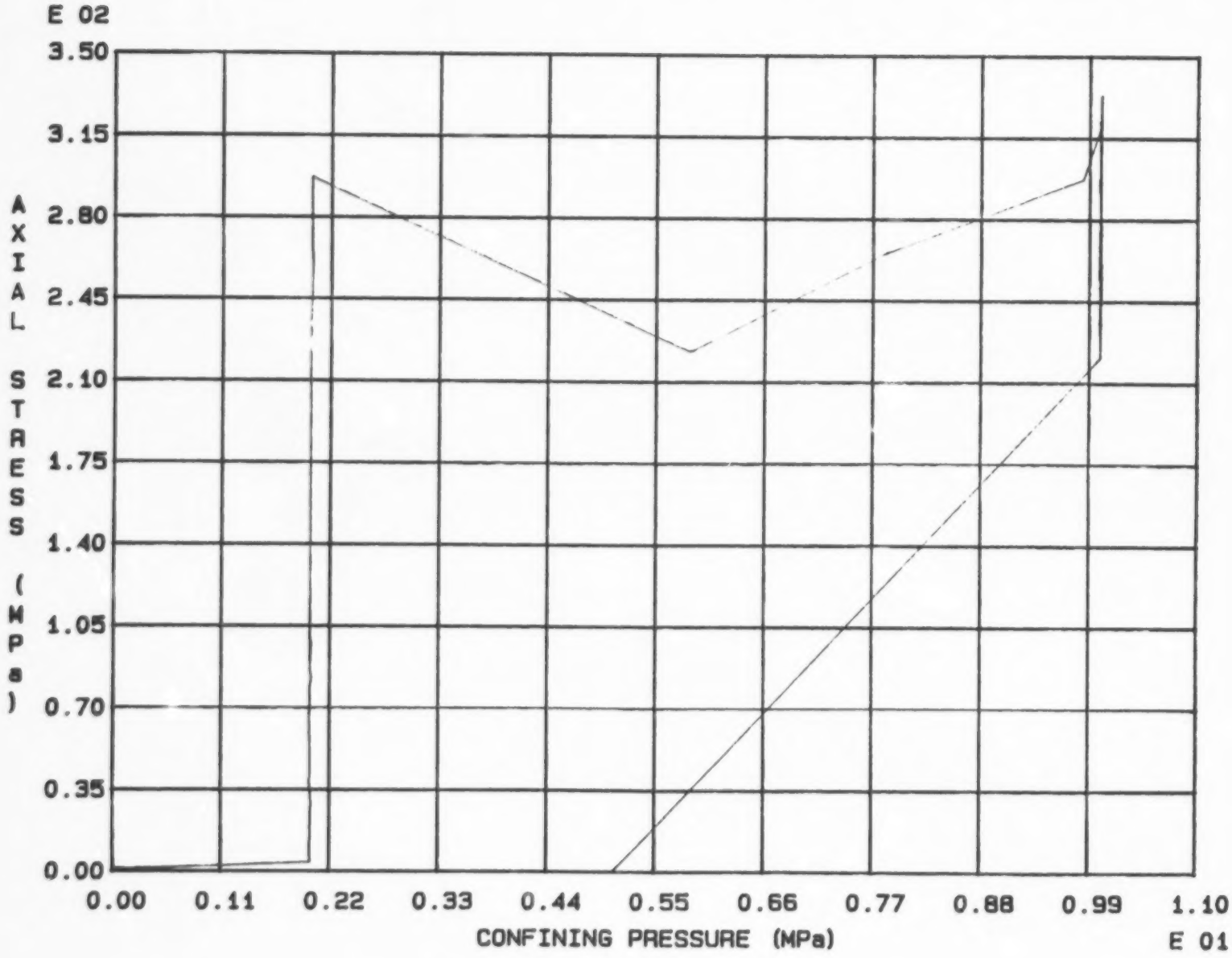

E 02
3.50
3.15
2.80
2.45
2.10
1.75
1.40
1.05
0.70
0.35
0.00
AXIAL STRESS (MPa)
0.00
0.11
0.22
0.33
0.44
0.55
0.66
0.77
0.88
0.99
1.10
CONFINING PRESSURE (MPa)
E 01

Fig. 6-43 E96M

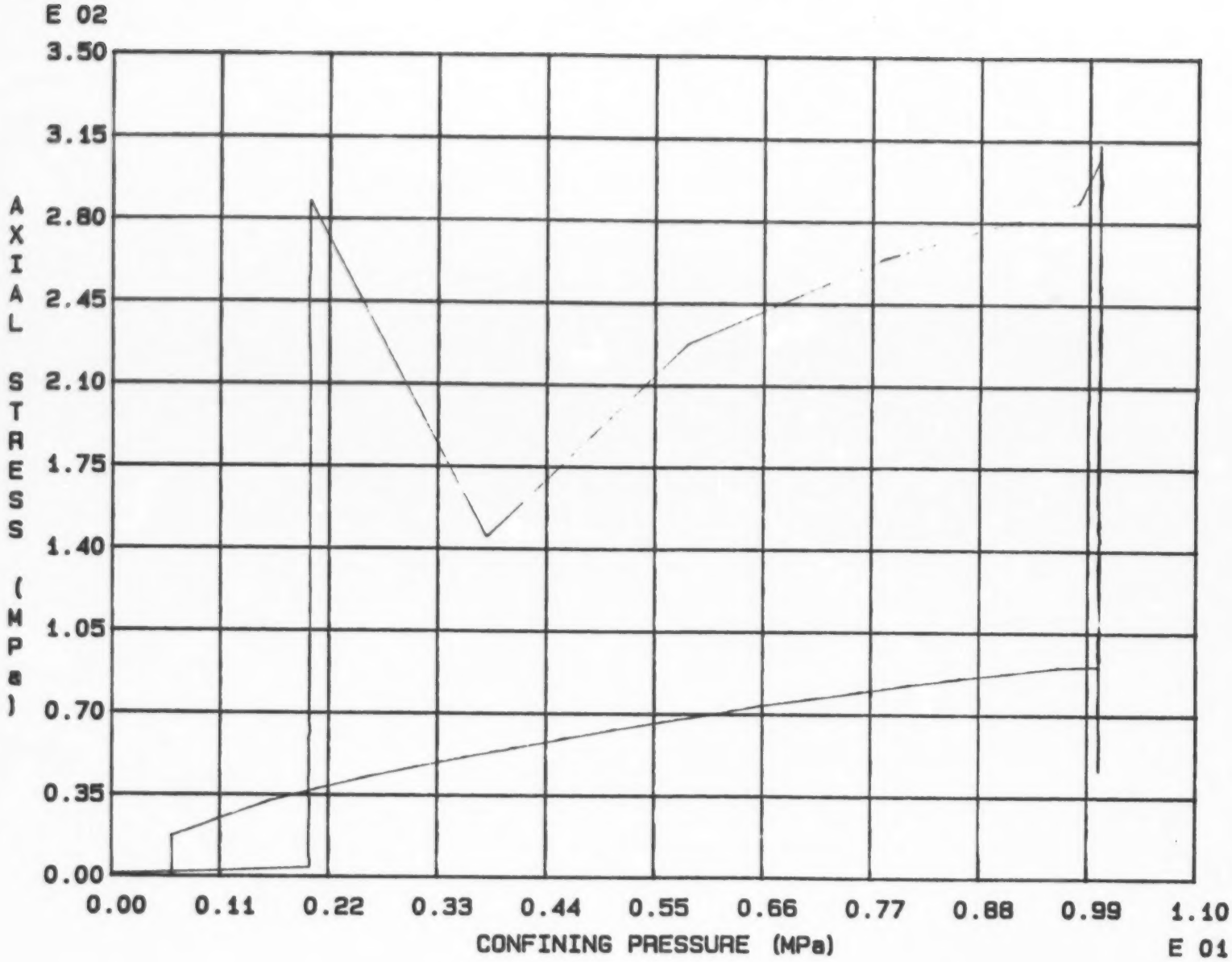

E 02
3.50
3.15
2.80
2.45
2.10
1.75
1.40
1.05
0.70
0.35
0.00
AXIAL STRESS (MPa)
0.00
0.11
0.22
0.33
0.44
0.55
0.66
0.77
0.88
0.99
1.10
CONFINING PRESSURE (MPa)
E 01

Fig. 6-44 E97M

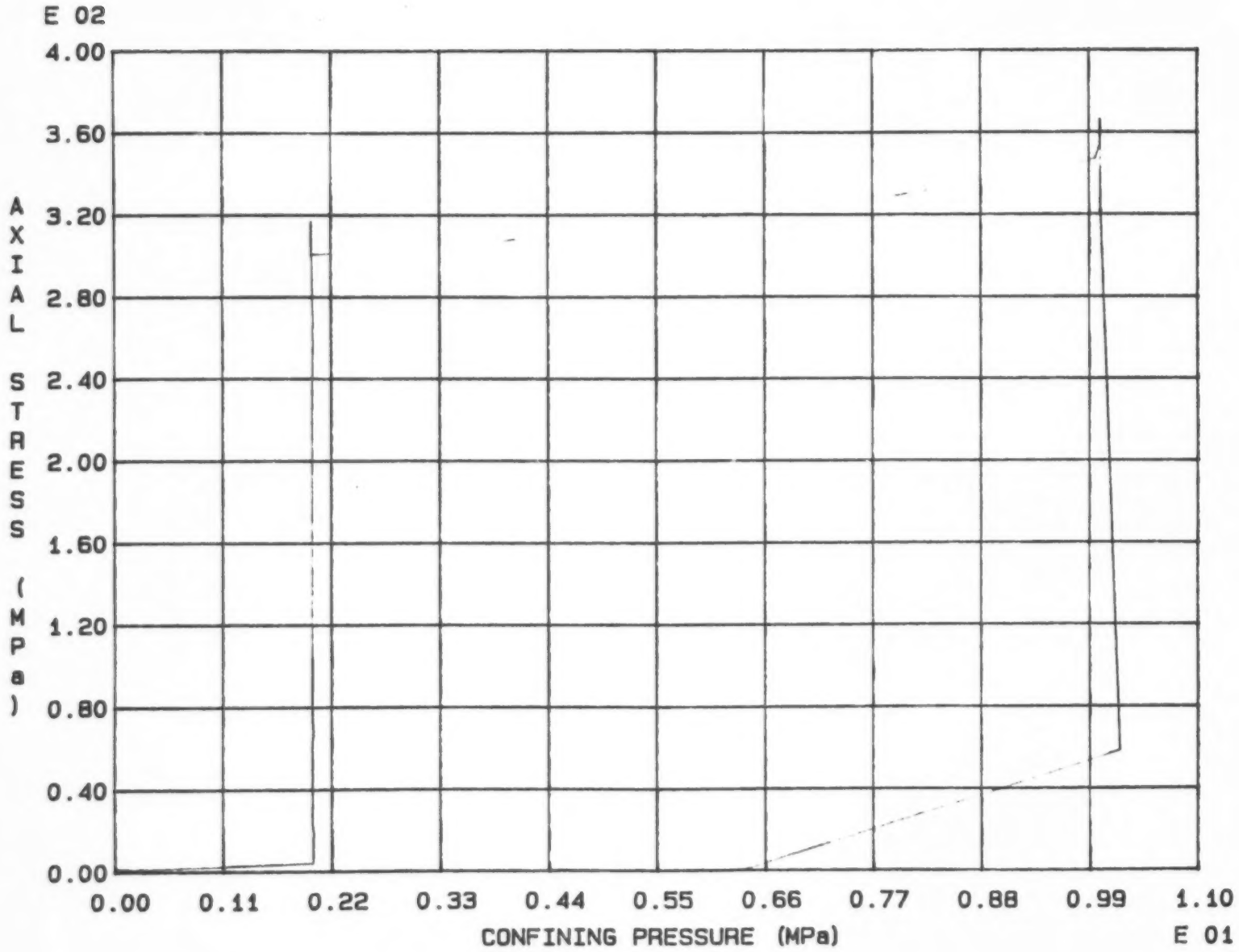

E 02
4.00
3.60
3.20
2.80
2.40
2.00
1.60
1.20
0.80
0.40
0.00
AXIAL STRESS (MPa)
0.00
0.11
0.22
0.33
0.44
0.55
0.66
0.77
0.88
0.99
1.10
CONFINING PRESSURE (MPa)
E 01

Fig. G-45 E98M

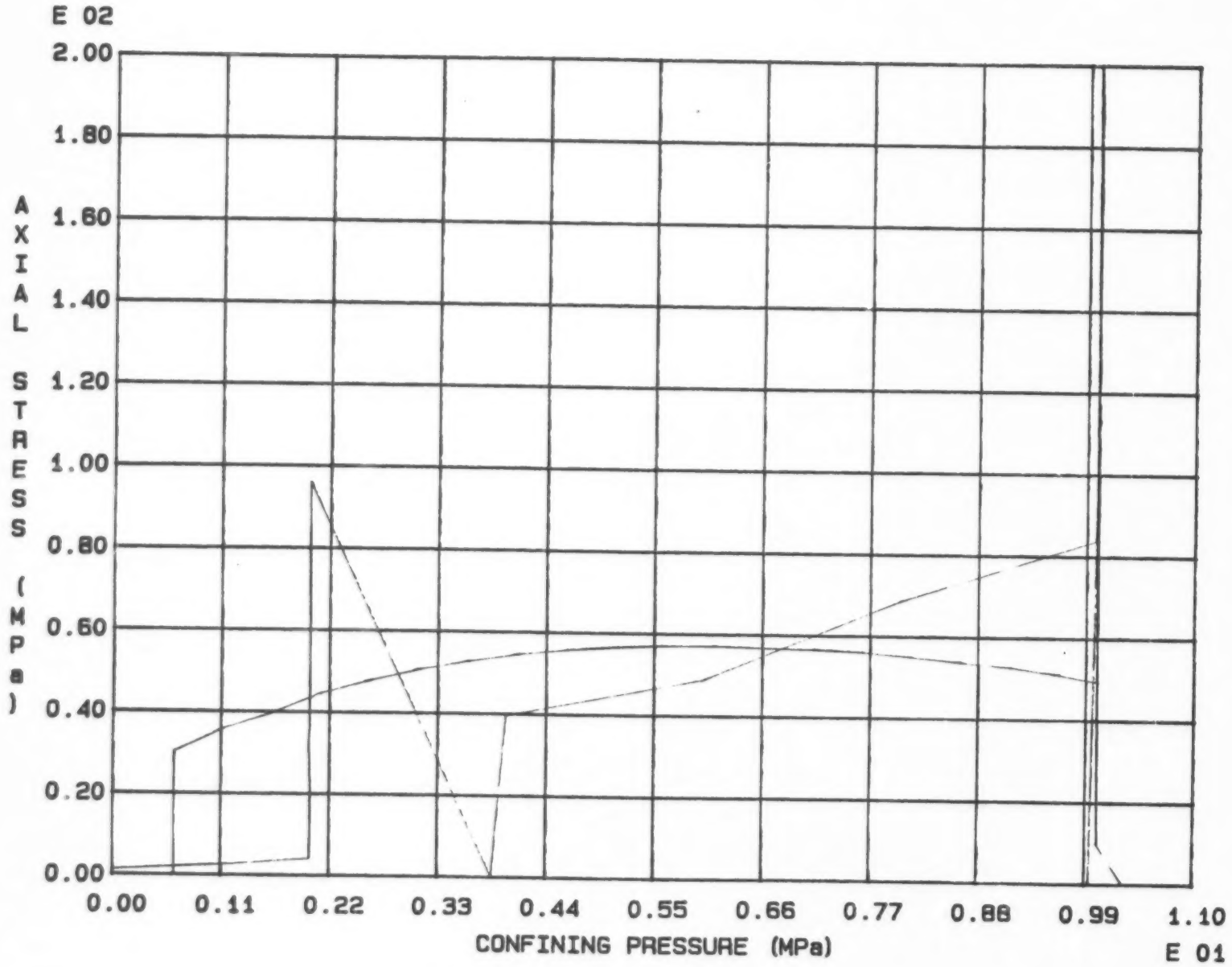

E 02
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
AXIAL STRESS (MPa)
0.00
0.11
0.22
0.33
0.44
0.55
0.66
0.77
0.88
0.99
1.10
CONFINING PRESSURE (MPa)
E 01

Fig. 6-46 E99M

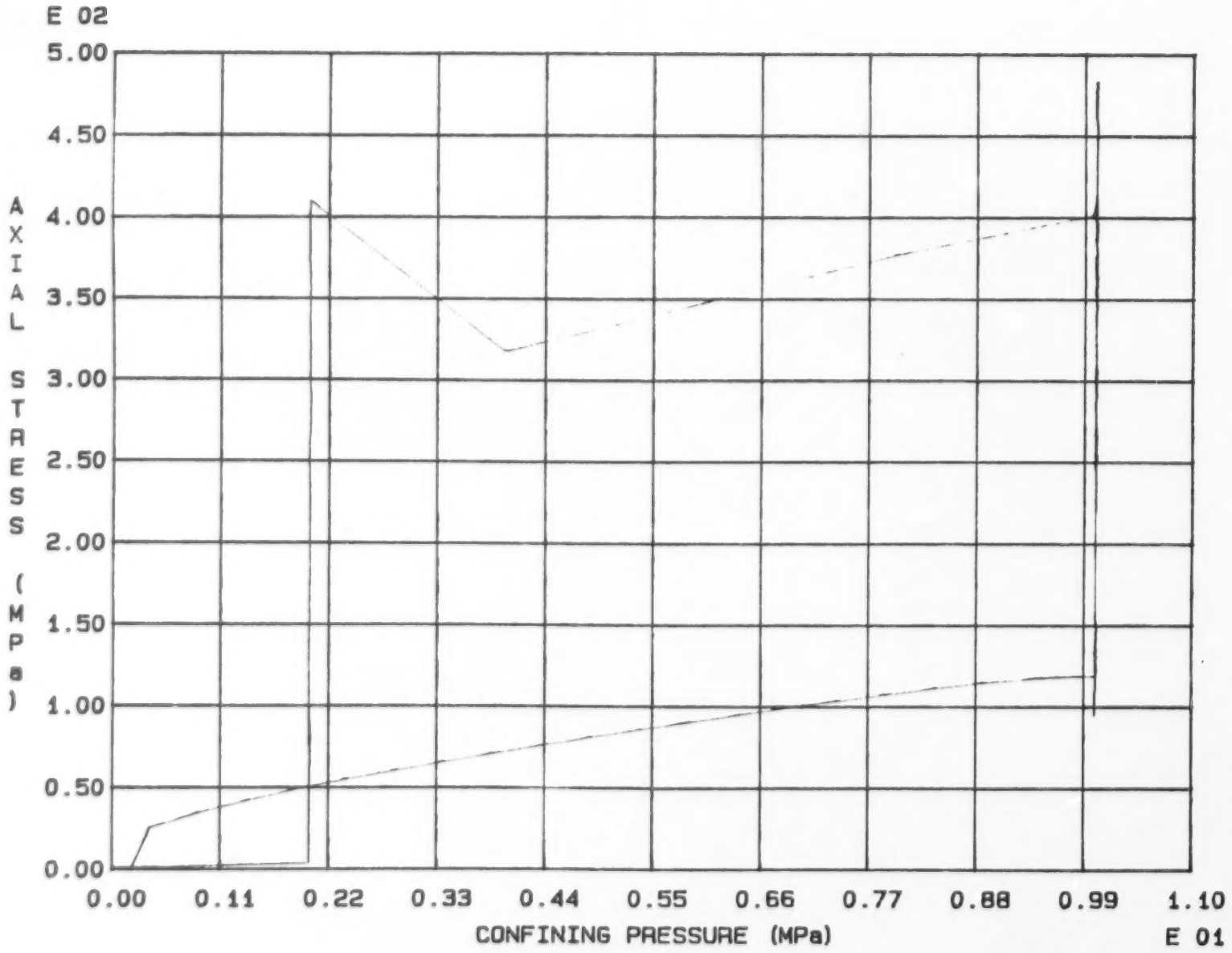
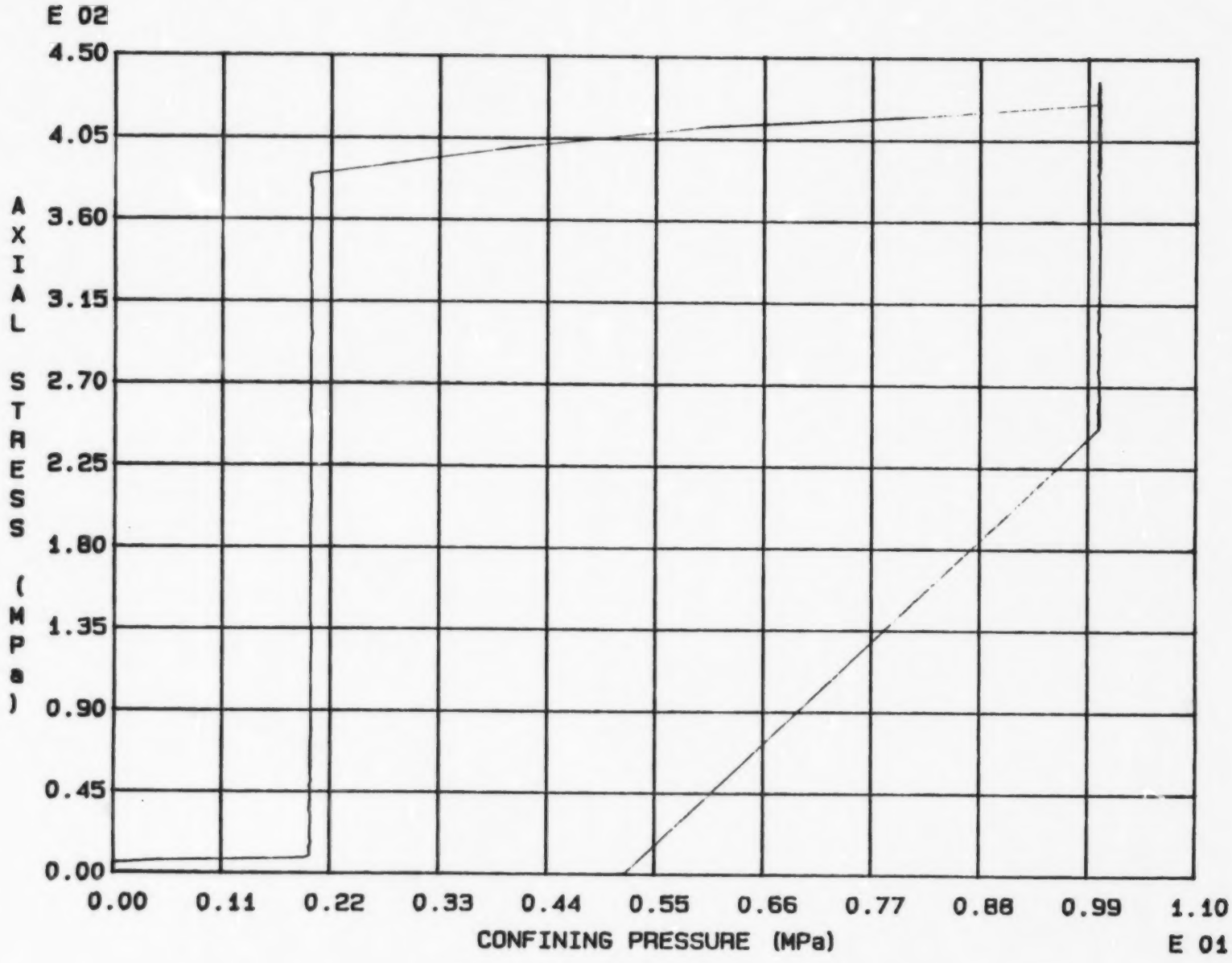


Fig. G-47 E100M



Fig, 6-48 E101M

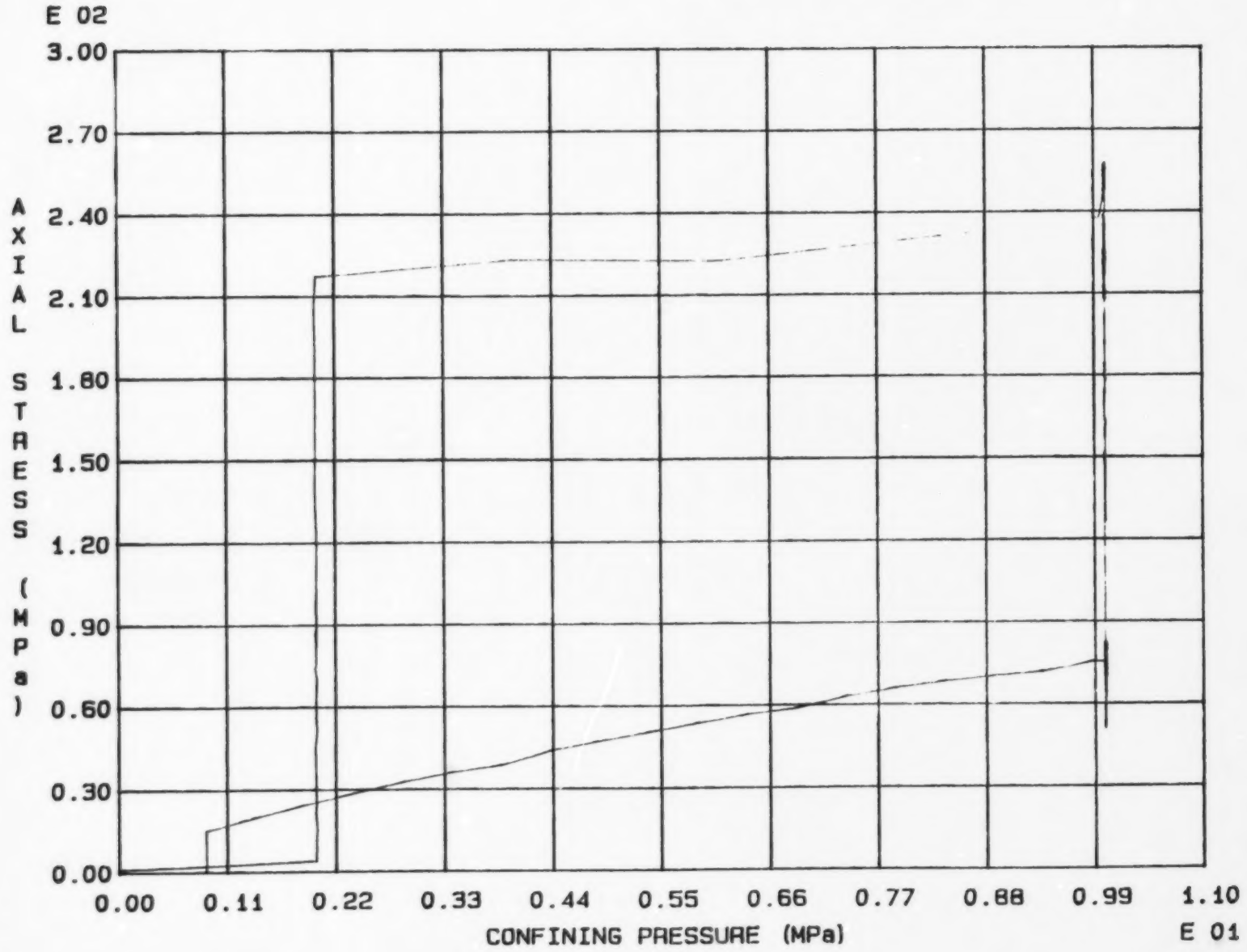


Fig. 6-49 E102M

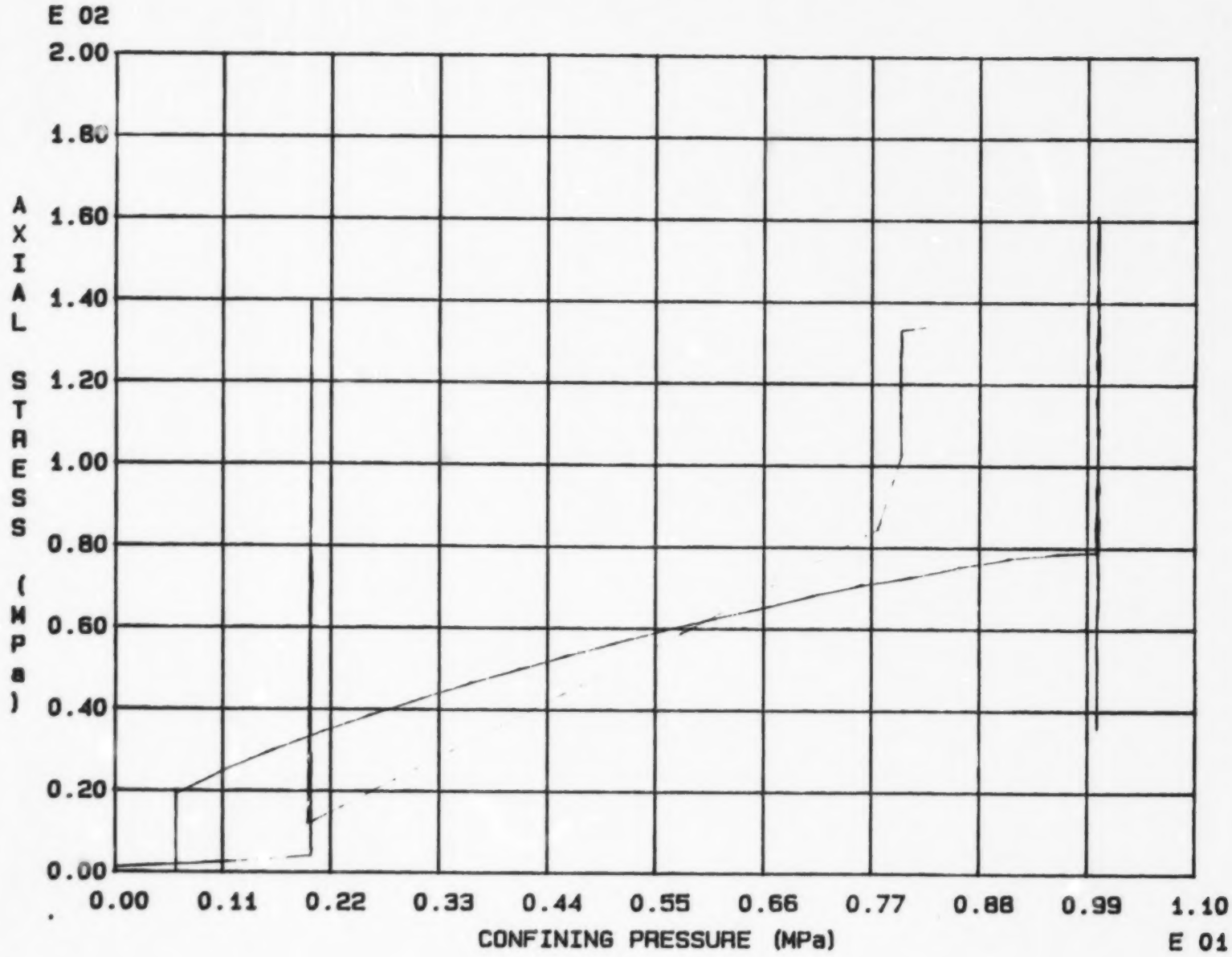


Fig. 6-50 E119M

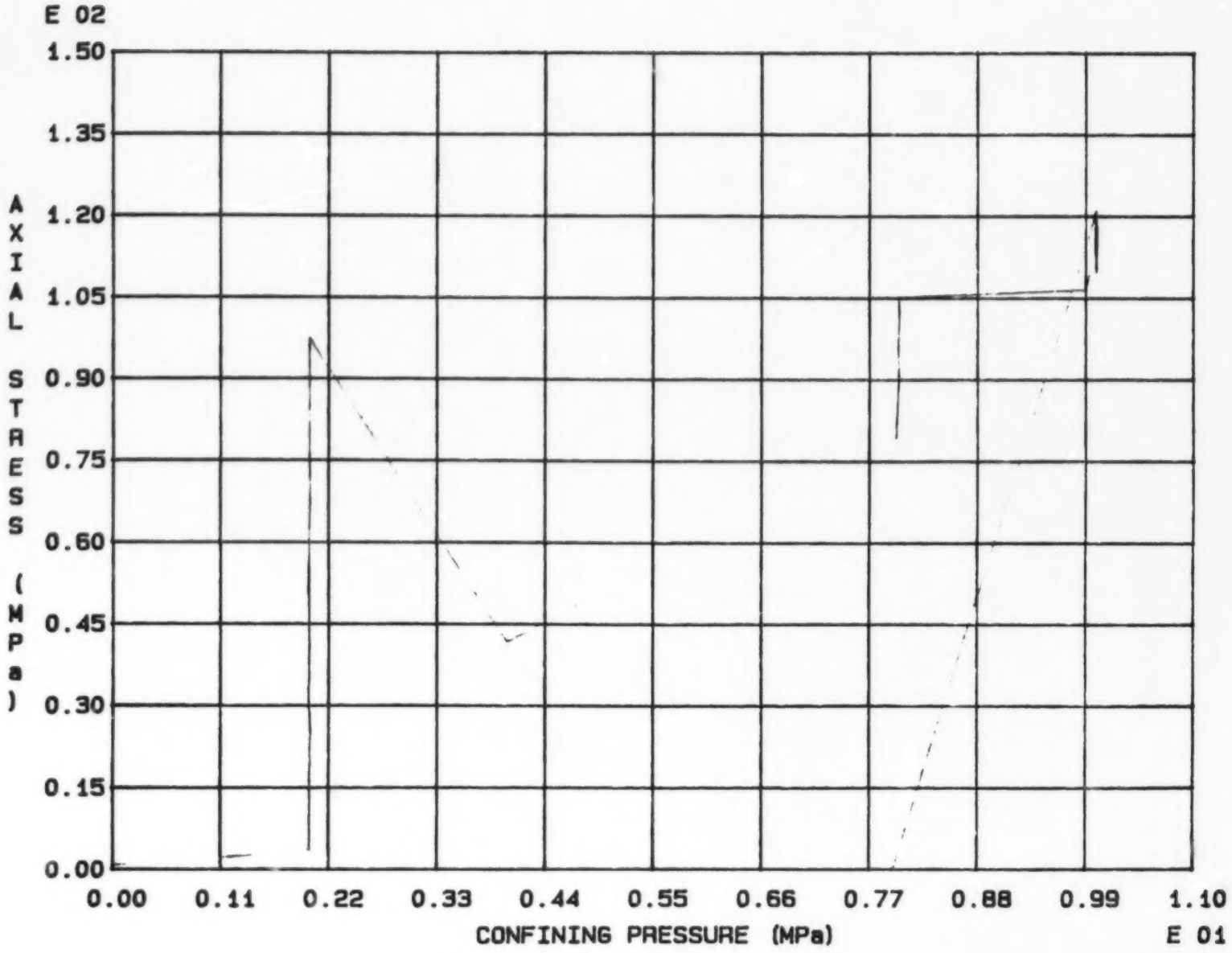


Fig. 6-51 E120M

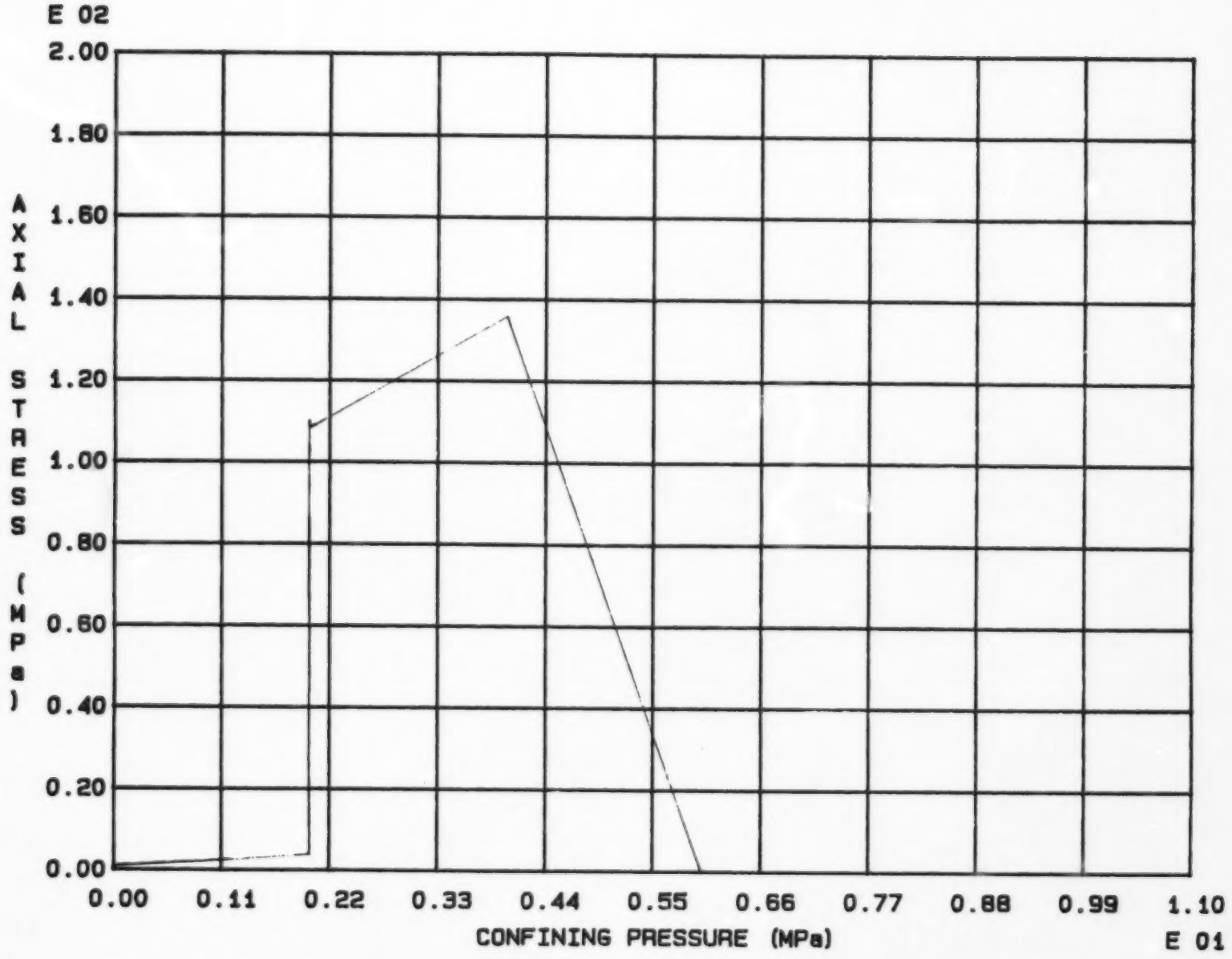


Fig. 6-52 E121M

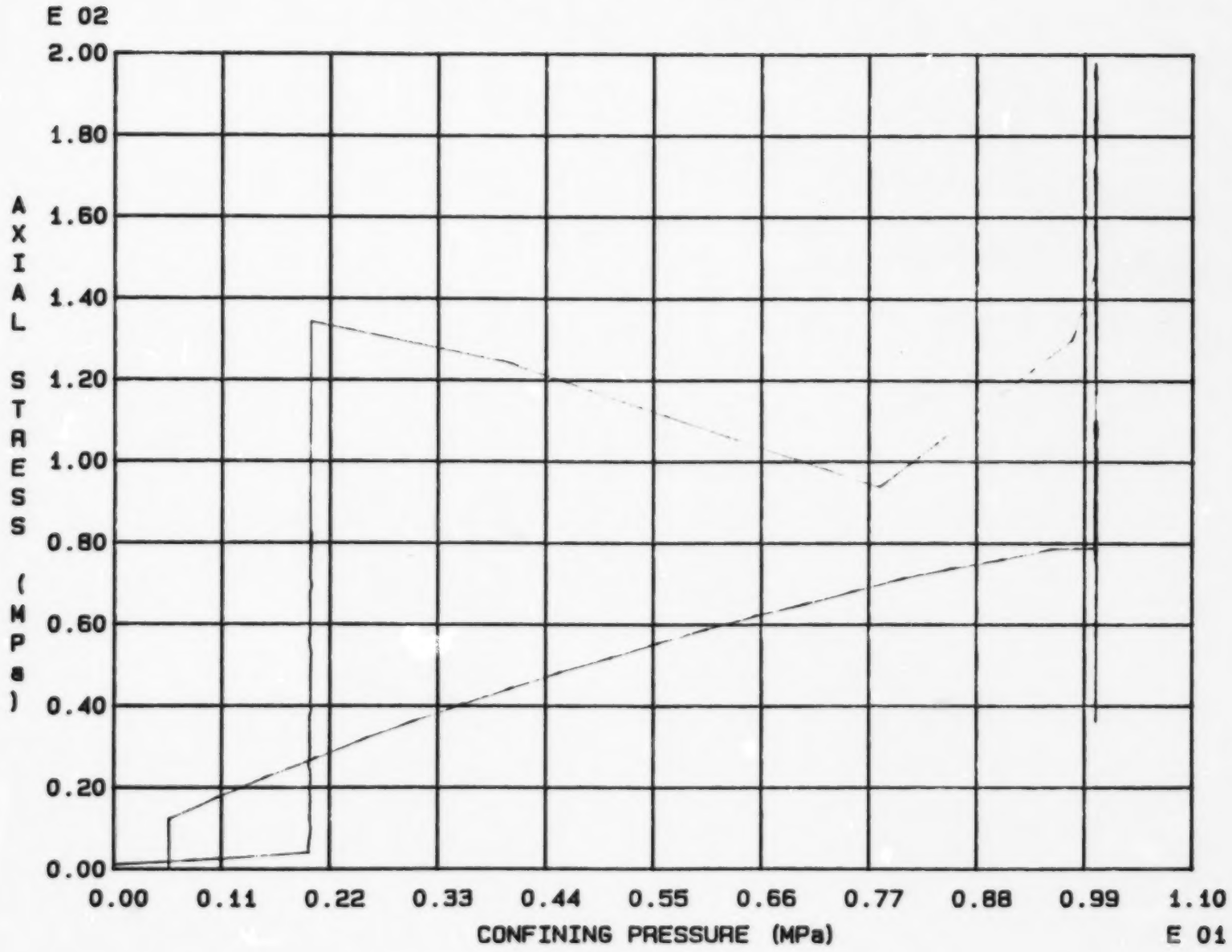


Fig. 6-53 E122M

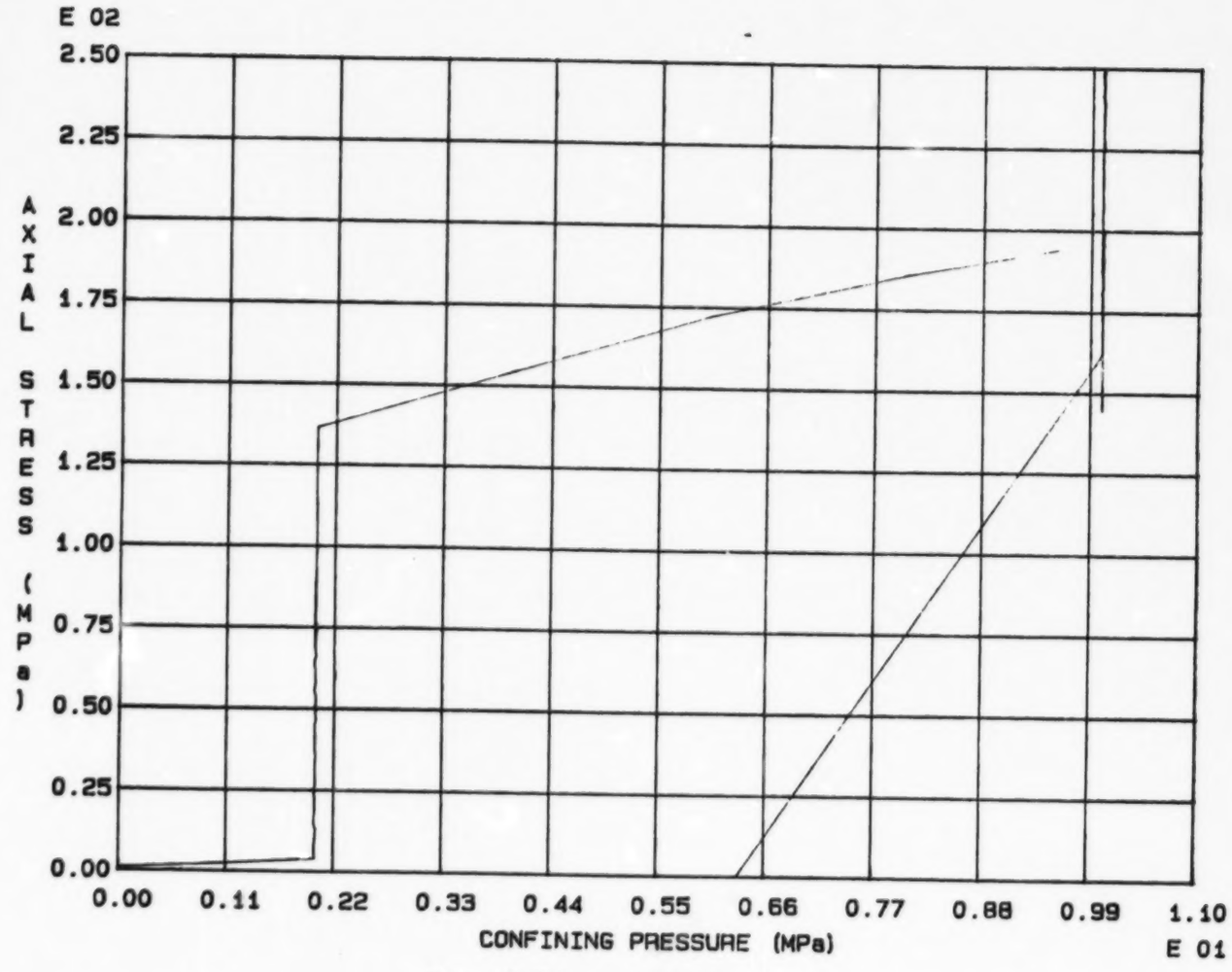


Fig. 6-54 E123M

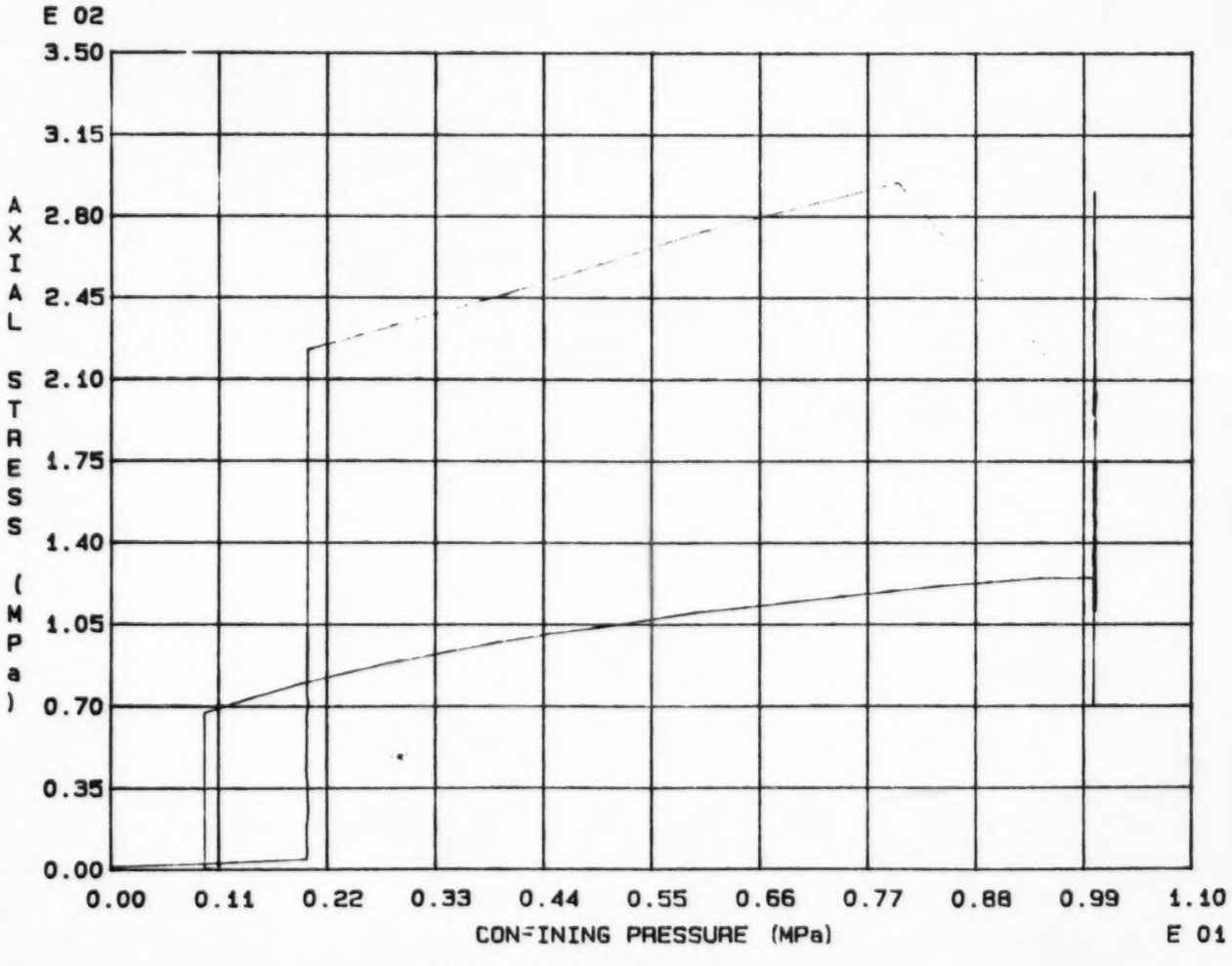


Fig. 6-55 E124M

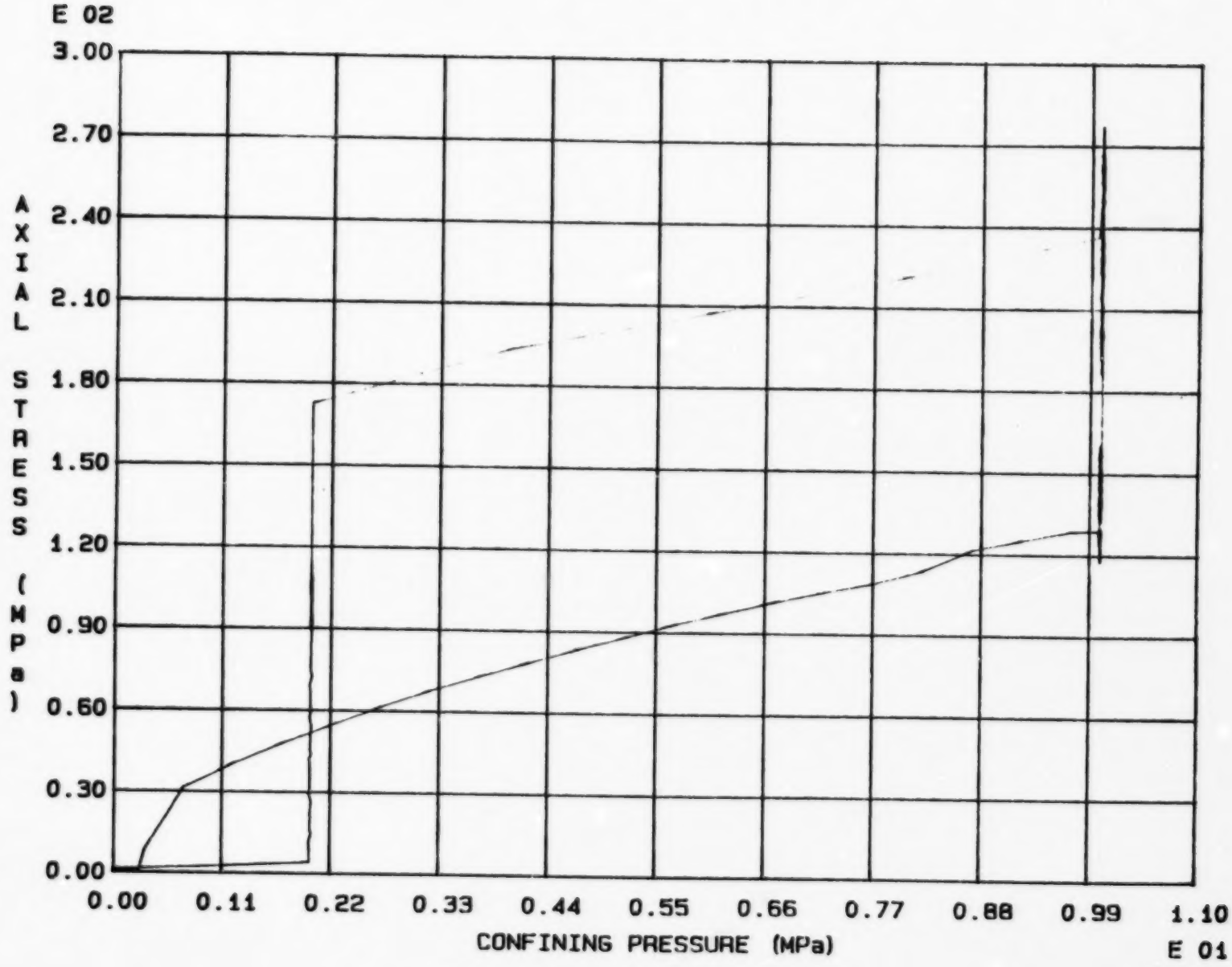


Fig. 6-56 E125M

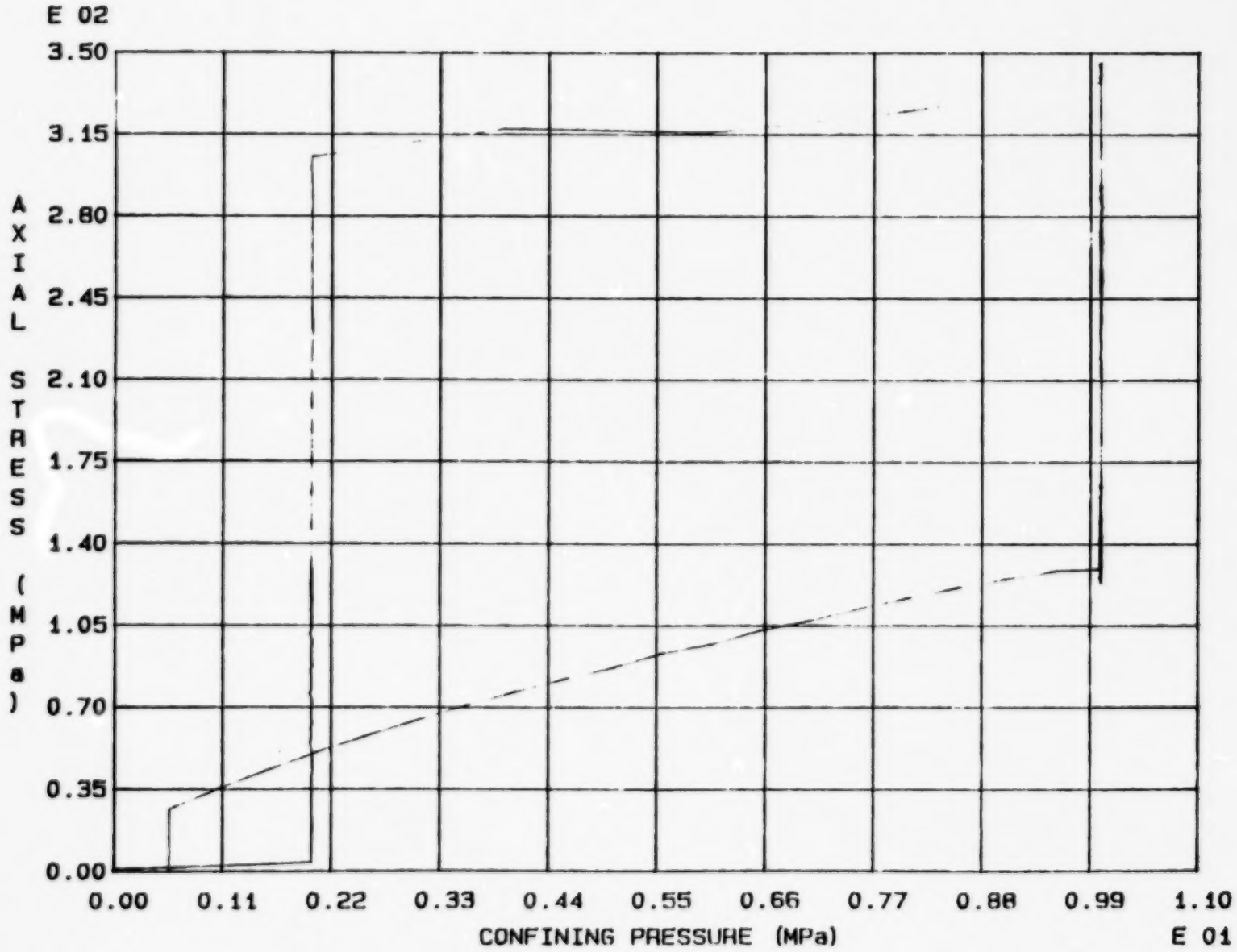


Fig. 6-57 E126M

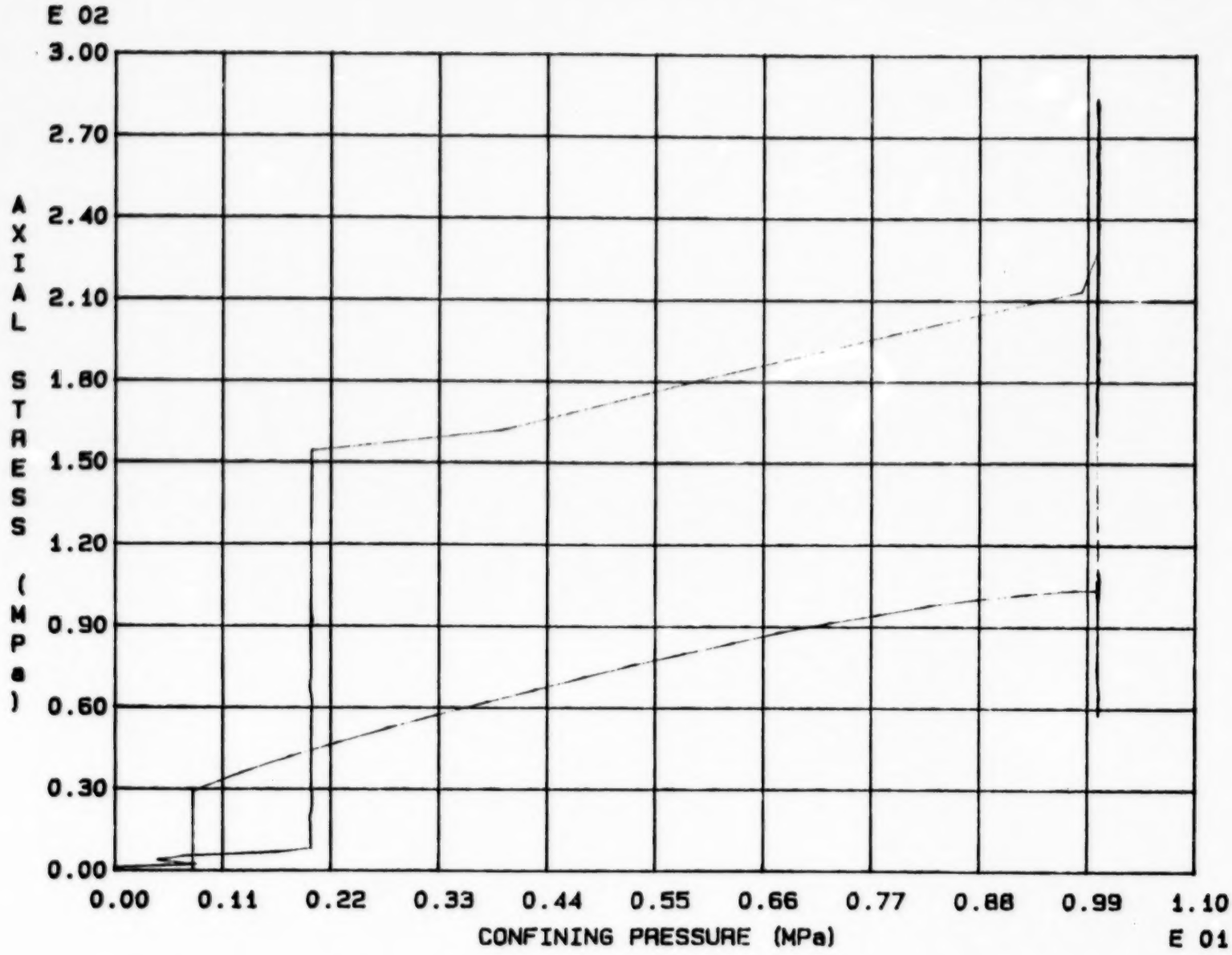


Fig. 8-58 E127M

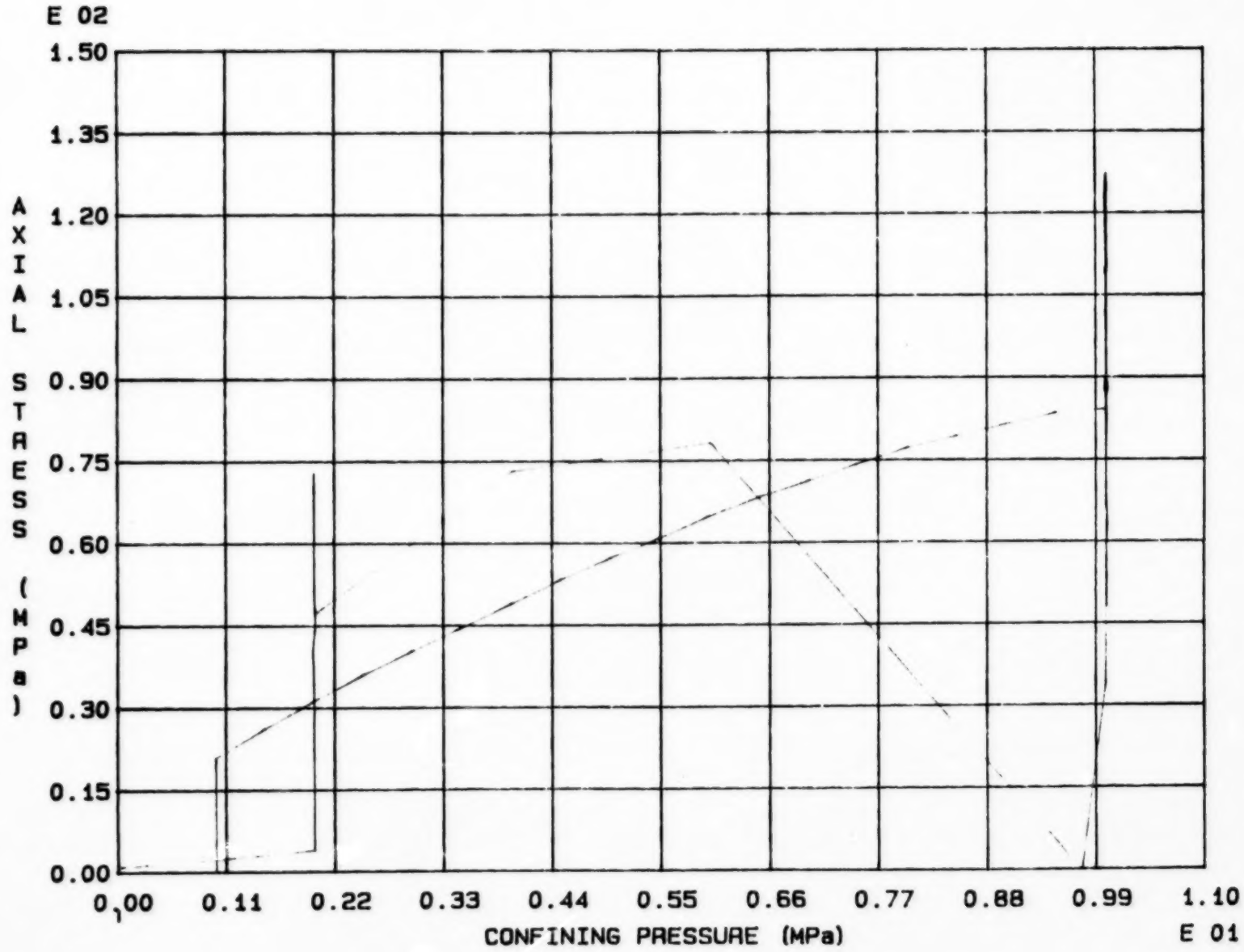


Fig. G-59 E128M

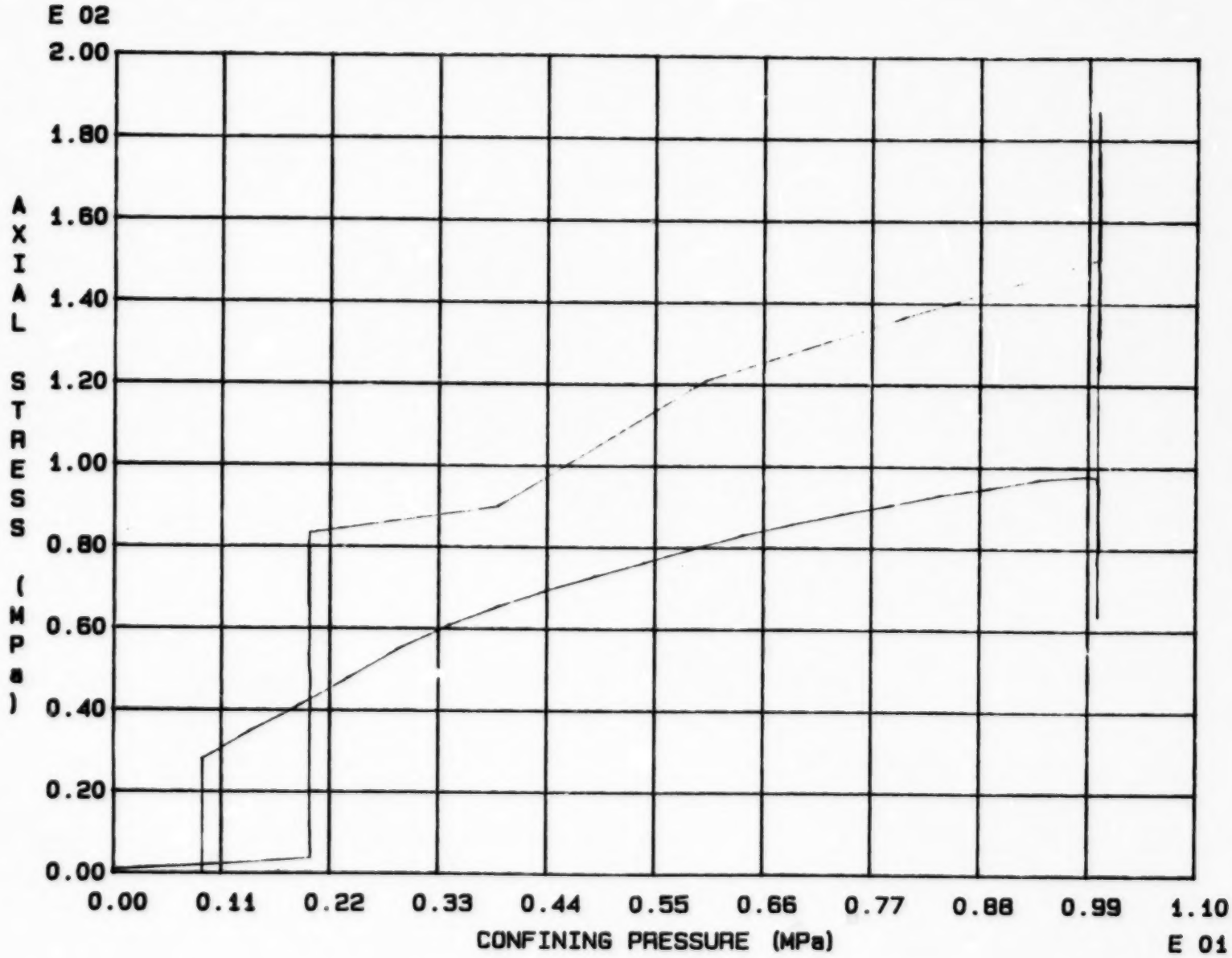


Fig. 6-60 E129M

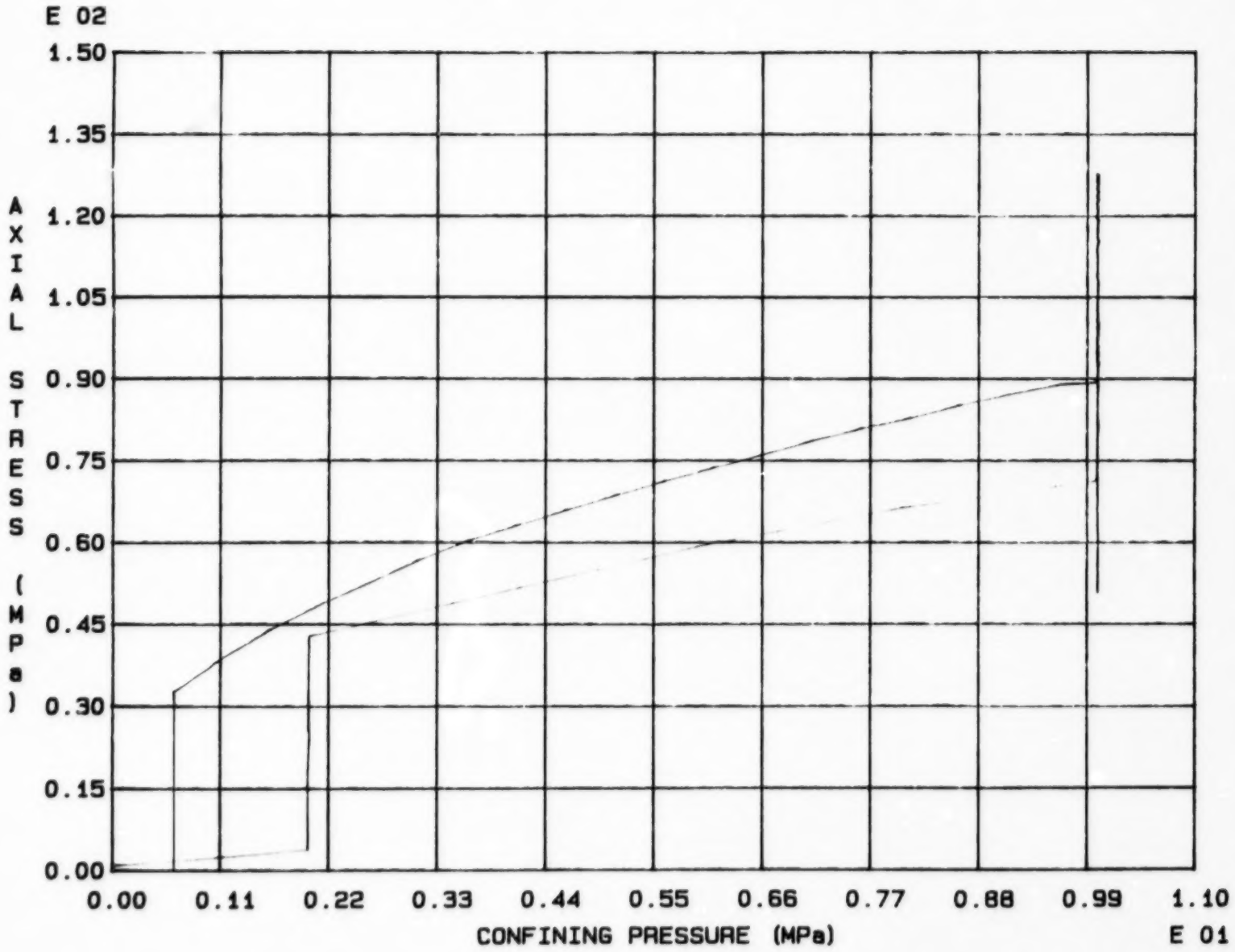


Fig. 6-61 E130M

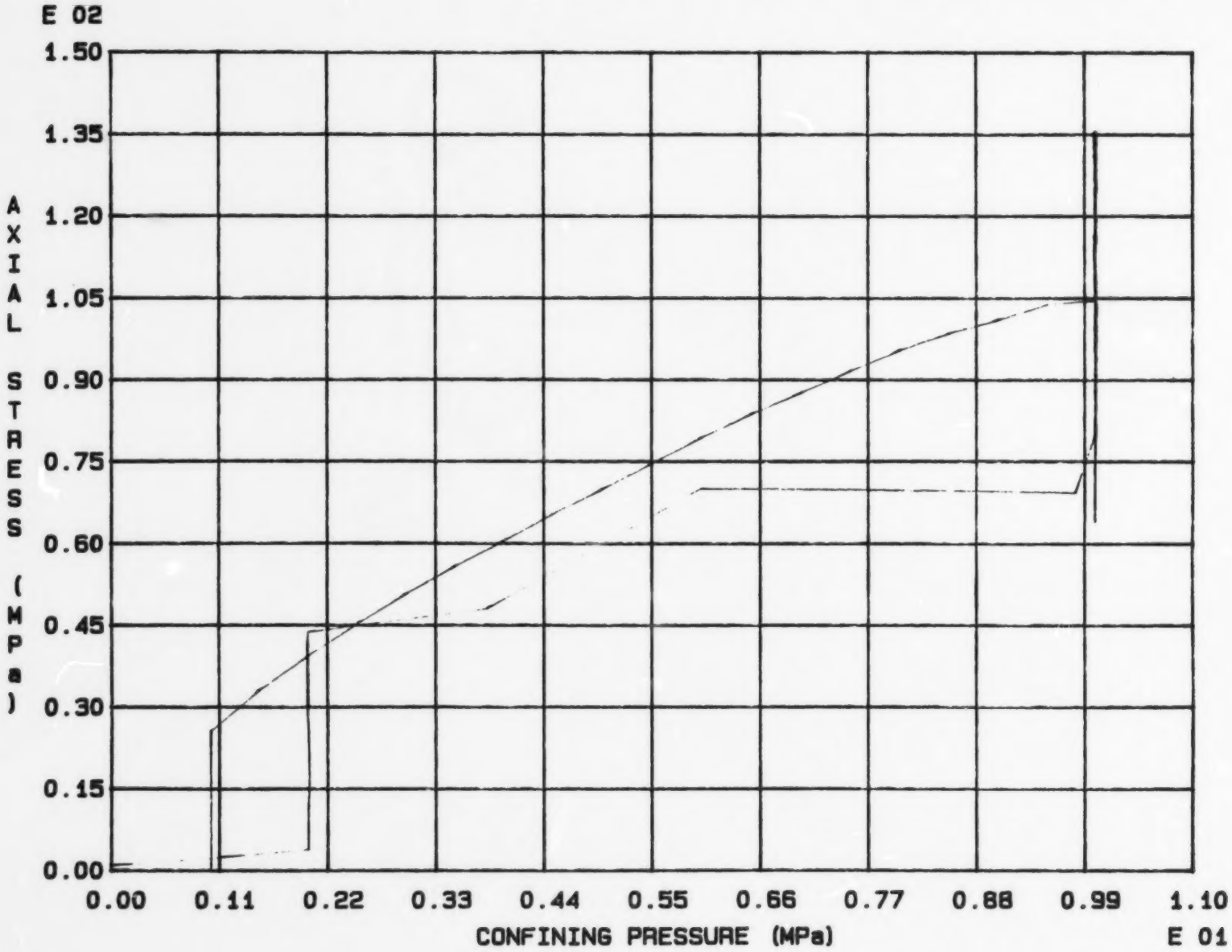


Fig. 6-62 E131M

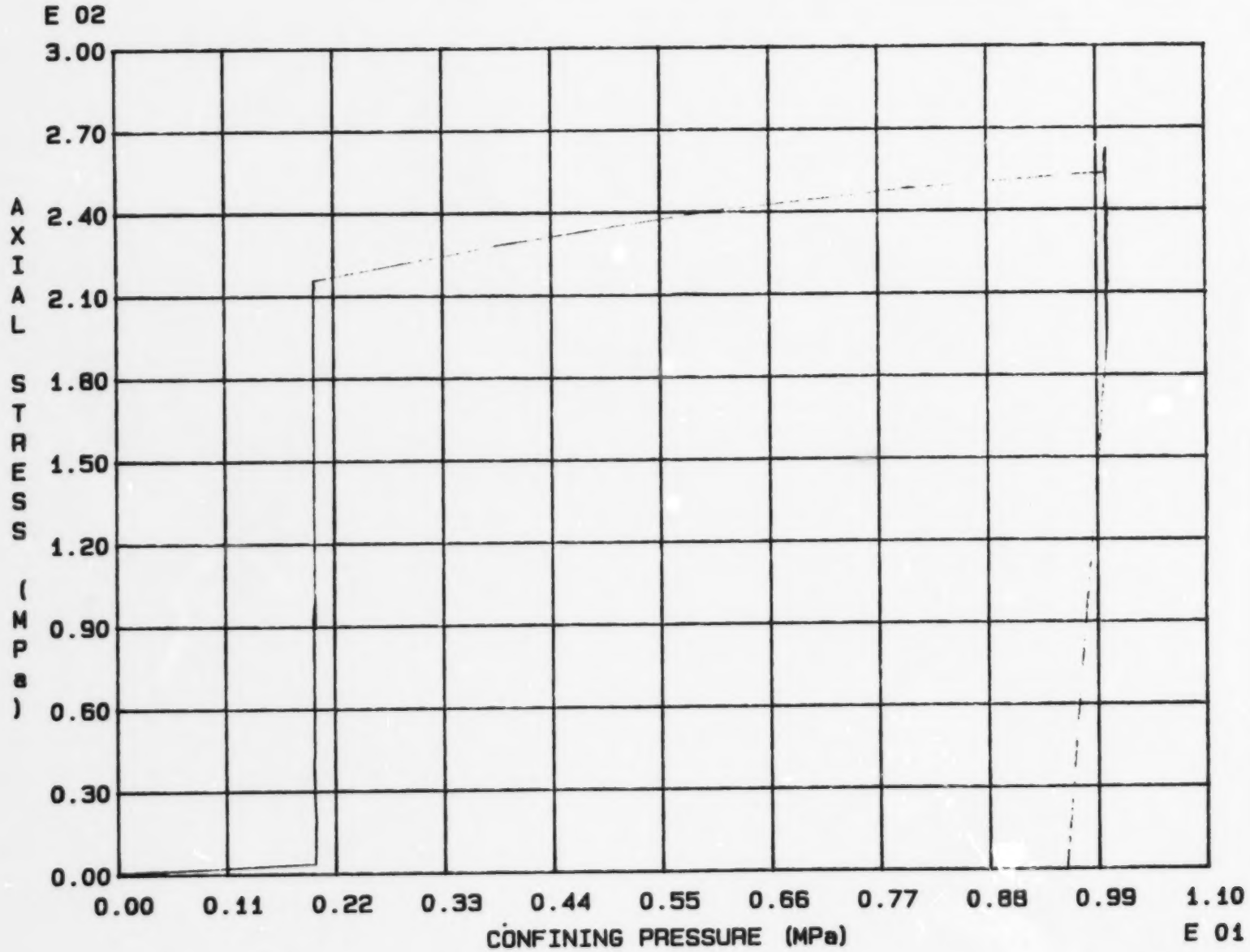


Fig. 8-63 E132M

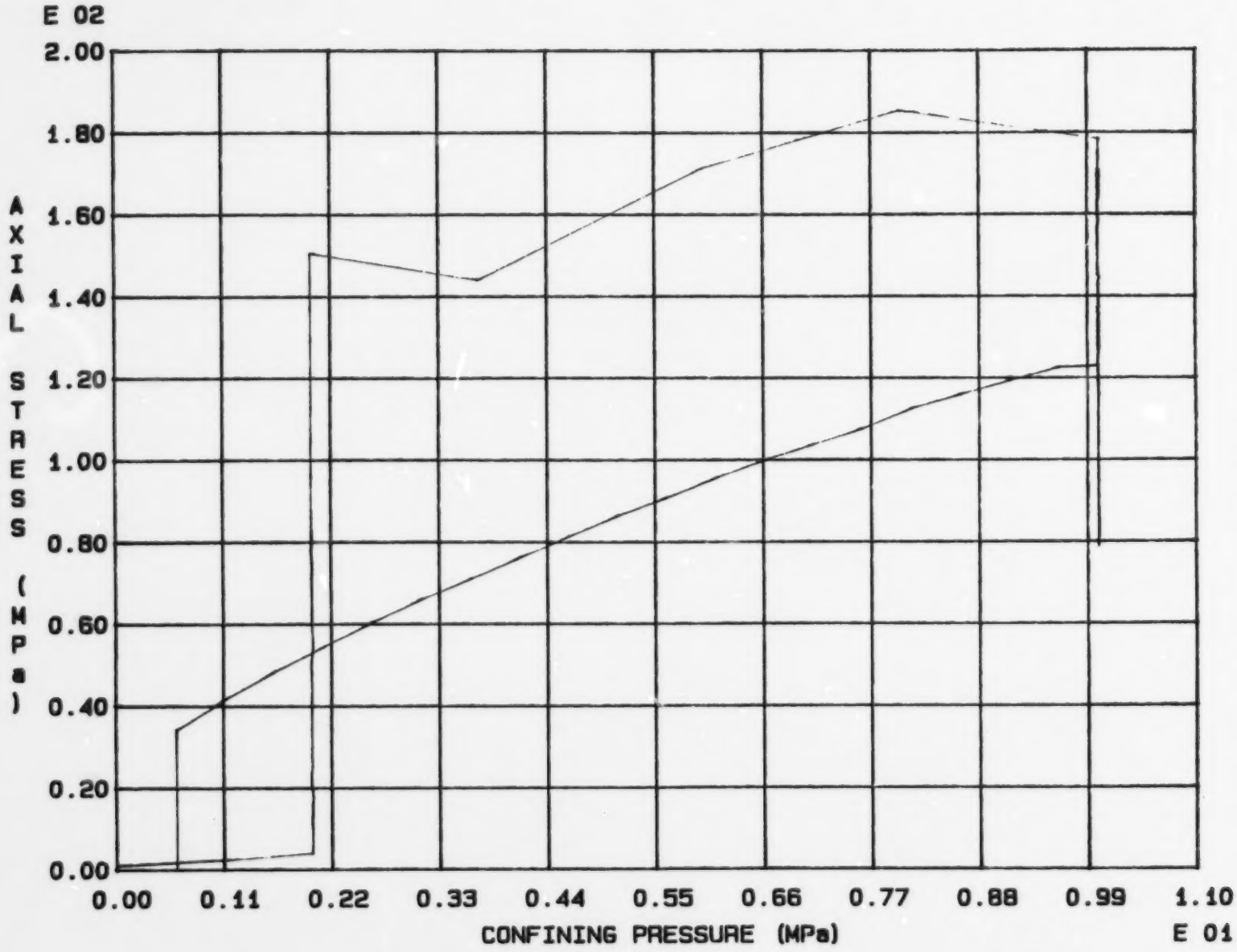


Fig. 6-64 E133M